

ALLIS-CHALMERS
Electrical
REVIEW



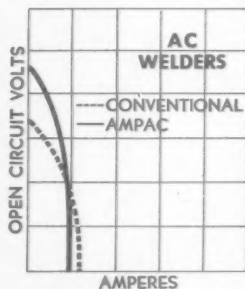
December 1945

AMPAC'S PATENTED CIRCUIT GIVES YOU Magic Arc Control

with Correct Striking Voltage Every Time!

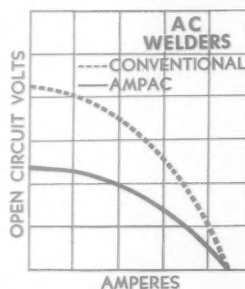
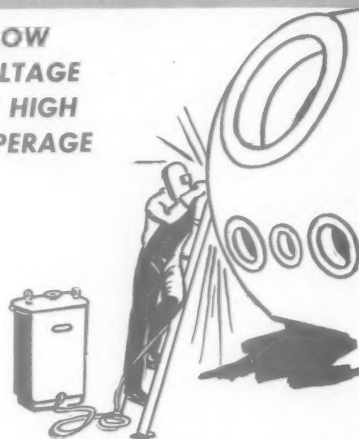


HIGH
VOLTAGE
AT LOW
AMPERAGE



All Welders know that low amperage settings require higher arc striking voltage. But Ampac welder's patented circuit steps up this voltage automatically. Conventional transformer type welders have same open circuit voltage for both high and low settings.

LOW
VOLTAGE
AT HIGH
AMPERAGE



On high amperage settings Ampac automatically cuts down excess arc striking voltage. You get better power factor, lower power costs. And there's no dual control—no changing of taps! Ampac's magic arc control gives you correct striking voltage every time.



Secret of magic arc control lies in Ampac's patented circuit that automatically provides correct striking voltage for every amperage setting. It's typical of the fine engineering in all Allis-Chalmers welders.

A1937

GET THE COMPLETE AMPAC STORY

Contact our nearby welder dealer or district office for full details on efficient, economical Ampac welders with magic arc control. Also inquire about A-C's complete line of electrodes and welding accessories. ALLIS-CHALMERS, MILWAUKEE 1.

ALLIS  CHALMERS

HEAR THE BOSTON SYMPHONY: Every Saturday Evening, American Broadcasting Co.



ULTRA-MODERN SETTING—a far-cry from the old blacksmith shop—forms background for new, streamlined electronic induction heater (cover). Scene is from "Metal Magic," a full-color movie now being produced by Allis-Chalmers to show growing applications of electronic induction heating throughout industry. Many of these, similar to the greatly simplified hardening operation being performed by the girl operator, are described in article on page 10.

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ALLIS-CHALMERS Electrical REVIEW



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CHOICE OF CORRECT WELDING RODS in the shop is important concern of good welding engineering, operators using rods specified on engineering drawings. Standardization of electrode classifications has helped to simplify this procedure, saving time and ultimately resulting in a better welded product.

Pick the Right Rod ...IT'S EASY

TECHNICAL details on heavy-coated electrodes are now available as a result of greater wartime need for specific information

E. P. GORMAN
Welding Engineer, Electrical Dept.
Allis-Chalmers Mfg. Co.

SINCE the introduction of heavy-coated electrodes for metallic arc welding in the early thirties, their manufacture has been surrounded with a veil of mystery. Welding rods were known by their trade names or by some peculiar color in the coating or color identification painted on the rod itself. That so little technical information was ever made available to the trade has been one of the riddles of the welding industry.

The war, however, greatly changed this picture—technical information had to be generally available because of the following factors:

1. Arc welding was used in the manufacture of almost every piece of war equipment. Consequently, Army and Navy standards for welding quality, including the use of approved types of electrodes, has to be met almost everywhere in industry.
2. The introduction of many thousands of unskilled workers as welding operators meant standards had to be simple and definite—choice of welding rods or technique could no longer be left with safety to the man on the job.

3. Many of the men placed in welding supervisory positions were engineers or technically trained men who had little previous knowledge of the welding industry. Their demand for more definite standards in welding electrodes required that electrode makers furnish full engineering information on all of their various brands of rods.

However, it was actually the American Welding Society which saw, many years before, the future possibilities of this great new industry and set the first generally accepted standards. One of the outstanding contributions of the Society, in cooperation with the American Society for Testing Materials, has been the classification of welding electrodes by number according to their welding characteristics and physical properties.

The numbering chosen by AWS-ASTM includes the following types of heavily coated electrodes: E-6010, E-6011, E-6012, E-6013, E-6020, and E-6030 for the welding of mild steel, plus other series for low strength or higher alloy steels. These numbers classify a rod by its tensile strength, welding position, and sub-group.

The first two digits specify the minimum tensile strength of the deposited metal in thousands of pounds per square inch. The third digit specifies the required welding position: one for universal or all-position, two for horizontal or flat fillets, three for flat position work only. The fourth number indicates sub-group according to chronological development of the AWS specifications.

Thus a type 6010 electrode means a rod with a minimum tensile strength of 60,000 lbs. per square inch for use in all positions, the specifications having been set up previous to others in the series. A small volume of rods with a very light or wash coating is still being manufactured, and these fall in the E-4500 series. Most manufacturers have developed the complete E-7000 series for low alloy steels, while series E-8000 and higher are beginning to appear on the market to meet the demand for high tensile, high alloy steels.

The descriptions following cover only the E-6000 series, but in general they parallel corresponding classifications in the higher strength series.

Type E-6010 most widely used

Since more than one-half of all electrodes used fall into this classification, it would be natural to assume that an E-6010 electrode must possess some outstanding properties. Although there is no universal electrode, the E-6010 type comes nearest to filling the role, and it has met the specifications of more testing bodies than any other single type. Besides the specifications laid down by AWS, at least nine¹ other nationally known organizations have their own electrode standards which must be met on certain types of work.

One of the leading features of this electrode is its penetrating arc. This characteristic insures good root penetration needed in a single "V" weld. Penetration is most desirable in tack welding, where the E-6010 is usually used, unless the

¹ Besides the specification listed by various city building codes, the bodies listed below have their own sets of standards. Most specifications conform closely to AWS-ASTM requirements, however.

Because of the expense involved, most manufacturers do not attempt to get approval from all bodies. Of the following standards, the most often quoted listings are those of the U. S. N. Bureau of Ships and American Bureau of Shipping:

a. U. S. Army Air Corps	f. Hartford Steam Boiler
b. American Bureau of Shipping	g. Lloyds Register of Shipping
c. A.S.M.E. Boiler Code	h. U. S. Coast Guard
d. U. S. N. Bureau of Ships	i. Merchant Marine Inspection
e. Dept. of Commerce B.M.I.N.	

fit-up is poor. This electrode operates only on reverse polarity d-c.

Weld metal produced by this type of electrode solidifies quickly, accounting for the good welds that can be obtained in vertical and overhead positions. This electrode is quite often referred to as a "cellulose" type, since a substantial amount of cellulose is found in the coating along with titanium dioxide, magnesium, or aluminum silicates and ferro-manganese, which produces a very desirable type of slag.

Further proof of the popularity of this electrode is found in figures recently released, showing that over one-half of all electrodes used in the shipyards were of this type, while 90 percent of the pipelines fabricated in the field are welded with an E-6010 electrode.

Recommended where quality of deposits made in vertical and overhead positions is of greatest importance, particularly where X-ray inspection must be met, main fields of application for the E-6010 include shipbuilding, bridges, storage tanks, and pressure vessels of all types.

Minimum AWS-ASTM Specifications of E-6010 Electrodes

	S.R.*	N.S.R.**
Yield Point, P.S.I.....	47,000	52,000
Ultimate Strength, P.S.I.....	60-72,000	62-80,000
Elongated, % in 2 inches.....	27	22

* Stress Relieved. ** Not Stress Relieved.

Type E-6011 is a-c counterpart

This electrode is basically a first cousin of the E-6010. The former was designed for d-c reverse polarity, while the latter is definitely an a-c rod.

The first E-6011 electrodes were marketed in 1942 as a result of the ever-increasing popularity of transformer-type welders, whose users in all phases of industry demanded an all-position electrode with the arc characteristic of the E-6010 type.

All alternating-current electrodes have to overcome a hurdle not found in d-c welding, because both arc voltage and current drop to zero 120 times each second, placing an extra premium on arc stability. In the E-6011 electrode all the problems associated with quality welding in all positions must be solved.

The coating of the E-6011 electrode is practically identical with that on the E-6010, with the addition of an alkaline compound of sodium or potassium—easily ionized chemicals to aid in obtaining better arc performance.

In welding, the E-6011 behaves much like the E-6010. Generally, the two rods are interchangeable in most specifications. The E-6011, although now sold in small volumes, is expected to gain in percentage volume—in line with the increasing use of transformer type welders.

Minimum AWS-ASTM Specifications of E-6011 Electrodes

	S.R.	N.S.R.
Yield Point, P.S.I.....	47,000	52,000
Ultimate Strength, P.S.I.....	60,000	62,000
Elongation, % in 2 inches.....	27	22

Type E-6012 provides smoother arc

In the early days of shielded arc-welding, the need was apparent for an electrode having a smoother arc than the harsh digging arc of the E-6010.

Name	E-6010	E-6011	E-6012	E-6013	E-6020	E-6030	E-7010	E-7020	E-7030
1. Tensile Strength, Avg. P.S.I.	68,000	70,000	70,000	70,000	66,000	66,000	90,000	75,000	77,000
2. Ductility, Average % in 2 in. (as welded)	25	23	23	20	33	35	26	30	30
3. Slag Removal	Good	Good	Fair	Excellent	Excellent	Excellent	Good	Excellent	Excellent
4. Bead Appearance	Rippled	Rippled	Fine Ripple	Fine Ripple	Smooth	Smooth	Rippled	Smooth	Smooth
5. Welding Speed	Slow	Slow	Medium	Med. Fast	Fast	Fast	Slow	Fast	Fast
6. D-C Reverse Polarity	Excellent	Good	Fair	Good	Good	Excellent	Excellent	Good	Excellent
7. D-C Straight Polarity	Not Used	Fair	Excellent	Good	Excellent	Good	Not Used	Excellent	Good
8. Alternating-current	Not Used	Excellent	Good	Excellent	Excellent	Good	Not Used	Excellent	Good
9. Penetration Depth	Deep	Deep	Moderate	Shallow	Deep	Deep	Deep	Deep	Deep
10. Overhead Usability	Excellent	Excellent	Fair	Good	Not Used	Not Used	Excellent	Not Used	Not Used
11. Vertical Up	Excellent	Excellent	Fair	Good	Not Used	Not Used	Excellent	Not Used	Not Used
12. Vertical Down	Fair	Fair	Good	Excellent	Not Used	Not Used	Fair	Not Used	Not Used
13. Poor Fitup Usability	Fair	Fair	Excellent	Excellent	Poor	Poor	Fair	Poor	Poor
14. Approval Codes Listed*	b, c, d, e, f, h	b	b, c	b	b, c, d, e	b, c, e	b	b, d, e	b, d, e

* Approval here means approval given to the electrode when used as properly applied. See footnote, p. 5, for listing of various approval agencies.

RECOMMENDATIONS FOR USE of welding electrodes in the E-6000 series for the welding of mild steel and in the E-7000 series for low alloy steels are given here as based on the performance of the line of electrodes introduced recently by Allis-Chalmers.

The solution of this problem resulted in the type E-6012 rod. A "cold" electrode like the early bare electrodes, it worked best with straight polarity, on direct current, and was known to the trade as a general purpose or "poor fit-up" rod. For single-pass fillets where maximum ductility is not required, the E-6012 electrode is ideal. Having a minimum of undercutting and practically no spatter, the rod has a slag that is easily removed, adapting it particularly to production work.

While designed for use on d-c straight polarity, good results with a-c welders are obtained from this electrode. It is noted for its shallow penetration, making it ideal for use on light gauge material, although there are many other uses—odd jobs of fabrication, general repair work, and the building up of worn surfaces with a minimum dilution of the base metal.

Laboratory men know this electrode as a "rutile" type and the following ingredients make up most of the coating: titanium dioxide, feldspar, aluminum silicate, magnesium silicate, calcium carbonates, and ferro-manganese.

Minimum AWS-ASTM Specifications of E-6012 Electrodes

	S.R.	N.S.R.
Yield Point, P.S.I.....	47,000	52,000
Ultimate Strength, P.S.I.....	60,000	62,000
Elongation, % in 2 inches.....	22	17

E-6013 is a-c general-purpose rod

With better alternating-current welders in the field, the need for an a-c electrode similar to the E-6012 was apparent. In 1941 the first electrode of the E-6013 type appeared on the market.

Basically the E-6013 is a general-purpose electrode quite like the E-6012 type, but the addition of a more easily ionized coating gives it greater arc stability, making it an ideal general-purpose rod for all transformer welders. In the sheet metal field the E-6013 rod is a "must" for the best appearing welds on such jobs as truck and auto bodies, heating and air-conditioning ducts, metal furniture, thin-walled storage tanks, window sash, and ornamental ironwork.

The superior arc stability of this electrode accounts for its wide acceptance in the aircraft industry, where thin sections of tubing must often be welded to heavier sections without burning through the former. As might be expected, most of the volume in small electrodes is in this type.

Minimum AWS-ASTM Specifications of E-6013 Electrodes

	S.R.	N.S.R.
Yield Point, P.S.I.....	47,000	52,000
Ultimate Strength, P.S.I.....	60,000	62,000
Elongation, % in 2 inches.....	22	17

Types E-6020 and E-6030 are new types

These are two of the higher speed electrodes that have appeared on the market in recent years. Designed to operate at higher current values without excessive spatter loss for work on 45 degree horizontal fillets and in the flat, the E-6020 enables the welder to deposit almost twice as much metal-per-hour as with the all-position electrodes.

Type E-6030 is used in the flat position only, its coating having low surface tension and little mechanical strength.

The E-6020 electrode can thus be substituted for the E-6030 rod. The converse is not true, however.

Called "hot" rods by operators because of the rapid deposition of metal, these electrodes should be used whenever permissible, since the strongest, most ductile, and smoothest welds are possible with them.

These electrodes perform well with a-c or either straight or reverse-polarity d-c. Heavy, uniform wide passes of weld metal can be made without fear of slag-entrapment on such applications as heavy pressure vessels or machinery structural sections. Extremely smooth beads allow easy cleaning of slag from the groove, simple hand tools usually found sufficient for all the cleaning required.

The coating on this type of electrode is very heavy, with as much as 20 percent of the total electrode weight contributed by the coating alone, usually composed of iron and manganese oxides with aluminum, magnesium, and sodium oxides as modifying agents. Sodium silicate is usually used as the binder.

The nature of these electrodes gives the weld deposit ductility values that are outstanding. Many "as welded" specimens will show an elongation of 30 percent in 2 inches, while stress-relieved pieces will test 35 percent or better. The thick blanket



of slag providing slow cooling probably contributes much to this high quality.

AWS-ASTM Specifications for E-6020 and E-6030 Electrodes

	S.R.	N.S.R.
Yield Point, P.S.I.....	47,000	52,000
Ultimate Strength, P.S.I.....	60,000	62,000
Elongation, % in 2 inches.....	30	25

Future standardization in intangibles

The AWS-ASTM specifications dealt with here are in reality only minimum standards. Impact resistance, endurance limits,

welding speeds, and spatter loss, etc., are not part of the standards, although many users consider such data fully as important as tensile strength and ductility.

Furthermore, as yet no way has been devised to measure the reaction of the welding operator in any set of specifications. Ease of striking the arc, amount of irritating fumes and smoke, "feel" of the arc, and arc stability in different positions are all hard-to-measure factors but mighty important when choice of electrodes is made. It is the appraisal of these intangibles that governs most electrode purchasing today. It is natural to expect that most improvements, then, will take place along those lines.

BASIC FACTS ABOUT ELECTRODES

LITTLE information has been published in the technical press on the manufacture of welding electrodes, since most manufacturers have spent long years and considerable money to develop their formulas in this highly competitive industry. However, a few of the interesting facts about electrode manufacture are listed below:

1. All electrodes for welding mild steel, i.e., types E-6010, E-6011, E-6012, E-6013, E-6020, and E-6030, use the same core wire—a good grade of rim steel, low in carbon. All variations, such as ductility, ease of welding, speed, tensile strength, etc., result from variations in the coating.
2. Rods are sold by the pound—prices in general run the same in the E-6000 series for most types and sizes larger than $\frac{1}{8}$ inch. E-6011 or E-6013 rods are slightly more expensive. Faster rods have heavier coatings, so rods actually cost more per pound of steel.

Good welding engineering demands that positioning and jig costs, labor skill and labor cost, rate of weld metal deposit and relative quality of final weld all be considered carefully before deciding on welding procedure on any production job.

3. Polarity is probably the least understood principle in the welding trade. The reasons that some electrodes operate best on reverse polarity and others on straight polarity are not fully known in many cases.

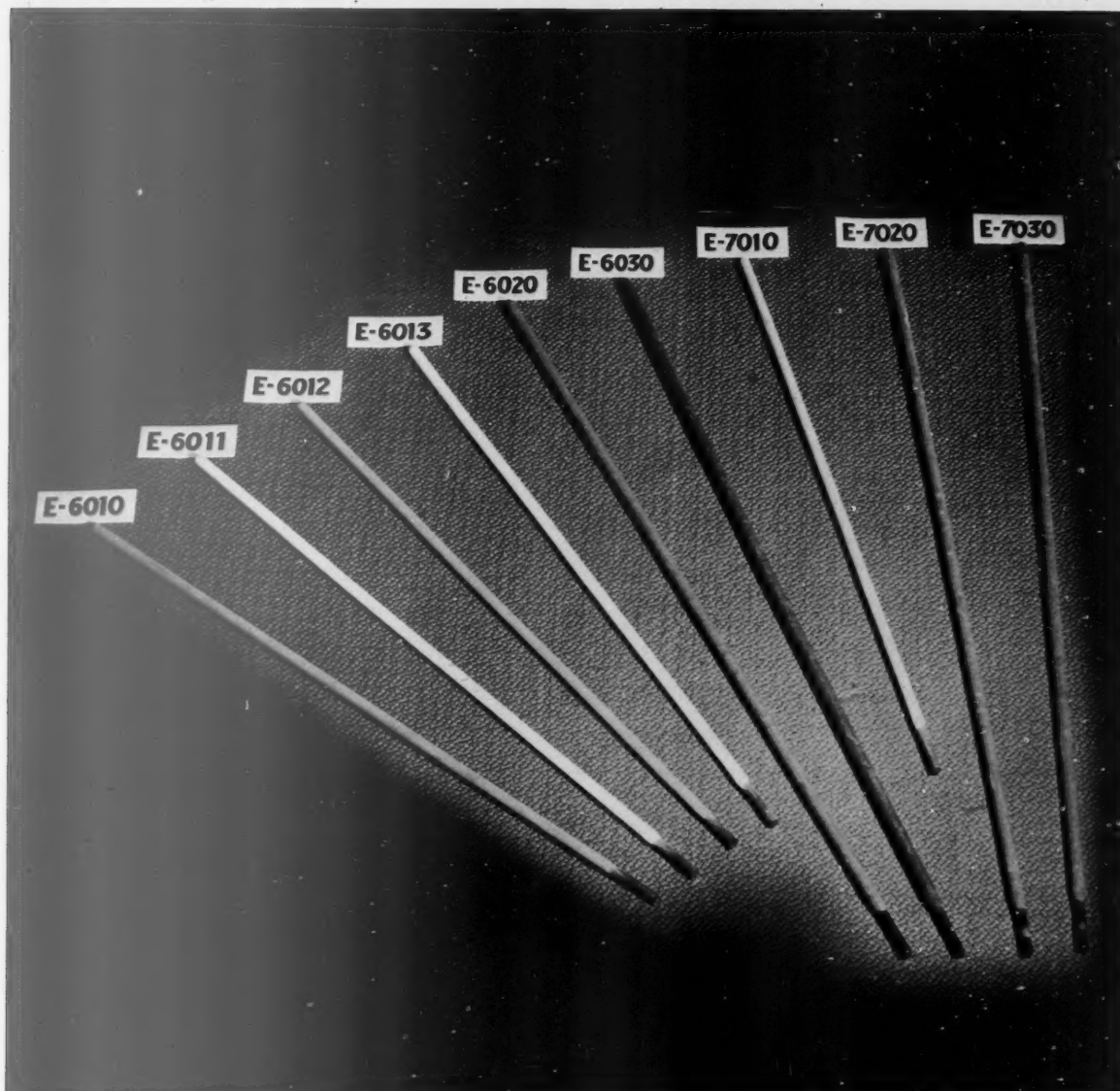
Bare wire is used on straight polarity with electrode on the negative terminal of welding generator, because more heat is developed at the positive terminal, thus better penetration is obtained when the electrode is connected in this manner. With coated electrodes the heat is more nearly equally divided between the anode and cathode. However, some electrodes such as the AWS 6010 type do not operate satisfactorily on straight polarity because of excessive spatter.

The development of electrode coatings to operate on straight polarity d-c and a-c has been largely by "cut and try." Most electrodes which operate well on a-c also operate satisfactorily on d-c. Sometimes these electrodes operate slightly better on either reverse or straight polarity but normally it makes little difference which polarity is used. To be satisfactory for a-c welding, electrodes should be practically neutral so far as polarity is concerned.

4. Coatings are made from over a hundred different minerals and organic chemicals ground to the proper degree of fineness, combined in endless ways by different rodmakers to gain the desired results, mixed in paste form, and extruded on core wire in a hydraulic press. Coating is brushed off at each end, color coding is applied, rods are run through a drying and baking oven, inspected and boxed. A single modern electrode production line might turn out two or three million pounds of $\frac{3}{8}$ inch rods a month.

Electrode coatings are used to perform as many as seven different jobs in the welding process, including:

- a. Mechanical support for the molten pool in vertical or overhead welding.
- b. Aids in striking arc.
- c. Provision of an ionized gaseous conductor to help maintain the arc.
- d. Formation of a cloud of gas through vaporization to keep atmosphere from molten metal.
- e. Creation of a molten slag for purification of the pool by floating out impurities.
- f. Creation of a solidified slag forming an insulating blanket over weld and thus providing annealing.
- g. Provision for a variety of alloys from a single core wire through addition of powdered alloys in coating.



STANDARD AWS NUMBER AND COLOR codes greatly simplify selection and handling of welding electrodes. For example, electrodes (above) in a new line recently introduced by Allis-Chalmers are readily identified with type names corresponding to the correct AWS-ASTM types. Thus, electrode codings correspond to specifications on drawings from engineering departments.

NEMA Two-Color Chart for Electrodes

AWS Electrode Classification	End or Primary Color	Spot or Secondary Color
E-6010	None	None
E-6011	None	Blue
E-6012	None	White
E-6013	None	Brown
E-6020	Blue	None
E-6030	White	None
E-7010	None	Green
E-7020	None	Red
E-7030	Blue	Green

**APPLICATIONS in
laboratory tests and
actual production set-ups
demonstrate the savings
possible with induction
heating**

INDUCED HEAT Rolls Up Its Sleeves

R. M. SEROTA

Electronic Devices Section, Allis-Chalmers Mfg. Co.

HIGH-POWER vacuum-tube oscillators for frequencies above 100,000 cycles per second are constantly proving to metal-fabricating industries that induction heating is an extremely useful, efficient, and economic tool.

Manufacturers who evaluate the efficiency of new methods of processing on the basis of whether they will help produce a better product or perform a given operation more economically are finding that high frequency induction heating equipment holds the enviable position of satisfying both objectives.

Although electricity is inherently an expensive commodity for heat generation, operation costs of this newest heating method are justified by the saving of time through selective hardening and rapid heating, uniformly good quality, reduction of rejects, and use of unskilled labor.

This is not to be construed as a prediction that induction heating will replace other means of heating, but that in several categories of applications, such as surface hardening, annealing, brazing, soldering, melting, and preheating for forging, it has unique advantages.

On the basis of both laboratory tests and actual production problems, the following applications clearly indicate the savings possible with this type of heating equipment.

Surface hardening savings

In surface hardening of steels, for instance, we find these savings:

1. Only a surface layer is rapidly heated, which prevents scaling and distortion and greatly reduces amount of heat required.
2. Carburizing process is eliminated by using a hardenable steel.
3. Copper plating of areas not to be hardened is eliminated, since induction heating makes selective hardening possible.
4. Time is saved by rapid heating and elimination of much work handling.
5. Induction heating is admirably adapted to production line set-ups, eliminating the storage and furnace space required for batch hardening.
6. Uniform case depth and surface hardness substantially contribute to reduction of rejects.
7. Because heat is developed only during actual hardening, the maintenance of heat during non-productive periods is eliminated.

Rocker arm adjustment screws which required a hardened ball, without change in the original structure of the threaded portion, represent a typical application. Formerly the threaded portion was copper-plated, the ball end was carburized and hardened, and the copper plate was then stripped away. This method using two heatings, however, distorted the threads and, since a thin carbon-proof copper plate is difficult to place on the threads, hard spots developed which caused easy breakage of the adjustment screw.

By induced heating of only the ball end of the screw, distortion of screw threads and annoying hard spots were avoided. In addition to eliminating the copper plating, carburizing, and stripping processes, roughly 20 percent of the former Btu was required.

Work-handling equipment with a conveyor can be set up in such applications to carry screws directly from the screw machines to the induction heater. A standard 20 kw induction heater is capable of hardening these screws at the rate of 200 pieces per minute, adequately handling the entire output of a normal battery of screw machines.

Thrust bearing surfaces present another problem. In one case the two side surfaces of a thrust bearing were to be hardened $\frac{1}{8}$ in. to $\frac{1}{16}$ in. deep to 58-62 Rockwell "C." S.A.E. 1144 steel was used.

By rotating the bearing in the work coil, heating and hardening were confined to the side surfaces without excessive heating of other shaft surfaces. Only three seconds for heating and another three to five seconds for water quenching were required. An automatic timer controlled heating and quenching cycles for absolute uniformity of the charge.

Annealing applications

Annealing of sheet, rod, and bar stock is another large field for induction heating. In such operations it is necessary to heat the entire mass, so no saving on the cost of heat occurs, but the ability of heating by electrical induction to fit into a production line set-up more than offsets the higher cost of heat. Annealing on a line set-up removes the necessity of working with batch lots, avoids excessive handling, and greatly reduces overall time. In addition, regulators and electronic controls can make the entire operation automatic.

Pinion shafts are customarily subjected to the carburizing process, with its subsequent distortion and hard spots on threaded parts. Annealing of the threaded end of the pinion shaft becomes necessary to remove these hard spots, as well as to relieve any stress set up during the machining and heat treating.



OF SPECIAL DESIGN for hardening shafts, this new 100 kw electronic heater is more powerful than most commercial broadcasting stations. Interior view of this unit, operating on a frequency of 400 kilocycles, shows, left—

high frequency oscillator with four water-cooled vacuum tubes; middle—high voltage rectifier six-phase system supplying 12,000 volts d-c; and right—160 kva transformer with associated switching equipment.

By designing work handling equipment with a conveyor to place pinion drives in the work coil, four or five arms can be heated simultaneously and satisfactorily at a rate of one every 15 seconds.

In annealing gears, the entire gear was initially case hardened to a depth of .030 in. to .040 in., leaving the internal surfaces to be finished. Machining economy demanded that the hardness of these surfaces be drawn from Rockwell '60 "C" to 30 "C" or lower. The remaining surfaces should not be drawn. The problem, therefore, was to confine the heat to the desired area and to raise it rapidly to the required temperature in order to prevent any appreciable conductance of heat to the other surfaces.

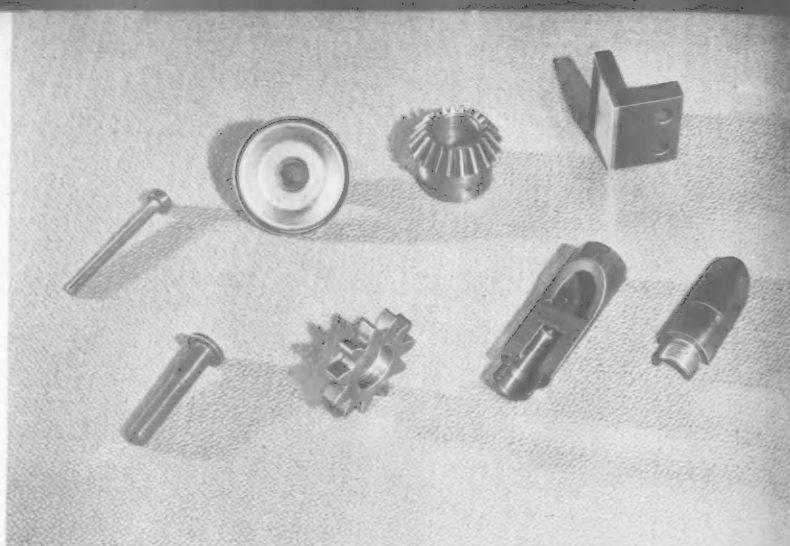
A single turn internal work coil was employed and the gear was revolved to obtain a uniform heating pattern. Less than 30 seconds was needed to anneal the surface to the depth required for machining. Thus the ability of induction heating equipment to produce a continual flow of material for the assembly line again proved to be of considerable advantage.

Brazing saves heat

In brazing operations the heat developed is confined only to the brazing area, saving heat over the furnace or torch methods which heat the entire piece to brazing temperature. It is not unusual to find a saving of 75 percent or more in the number of Btus required to do a given brazing job.



EIGHT SECONDS are required to harden thrust bearing surfaces; bearing rotation confines heating and hardening to side surfaces without excessive heating of other surfaces.



HARDENED OBJECTS are a pinion gear (top, third from left) and a spur gear (bottom, second from left). Brazed jobs are (top row) a contact stud, roller cup base, silver contact insert on copper, (bottom row) contact stud, and bomb fuse assemblies.

Similarly, because of the heat concentration and the higher power densities available (2 to 20 kw or more per square inch of surface area), brazing time usually consumes only a matter of a few seconds. The tremendous increase in production rates thus made possible results in a substantial reduction in unit costs.

Brazing, when done with induction heating equipment, is easily accomplished by unskilled labor. The operator applies flux to the components to be brazed, places a preformed ring of brazing alloy in position, assembles the components, puts the assembly in a work coil, and turns on the power. Work can frequently be set up on an automatic or semi-automatic basis.

Invariably the uniformity and quality of brazing far surpasses that of any other method. Parts having properly designed brazed joints can be made as strong or stronger than similar pieces machined from one-piece stock. Since manufacturers have discovered that important savings in machining and material costs can be realized by the use of induction heating equipment, many complex machining jobs have been redesigned to take advantage of these savings.

Brazing of four nipples and one seam on a mixing chamber, for example, was formerly done one area at a time by a gas torch, requiring from 1½ to 3 minutes for each of the five brazes. By induction heating, three threaded nipples brazed

per hour was gained without additional labor costs over the 6-10 per hour produced by the torch method.

Brazing saves machining

Roller fabrication illustrates the saving that can be achieved by brazing several steel pieces instead of machining the components. A shaft is placed inside a cylinder with end bells put on each extremity. Both shaft and cylinder are simultaneously brazed to the end bells in two operations, each taking approximately 10 seconds. Since the heat is developed uniformly around the piece, the joints are pressure-tight and stronger than specified, no warpage occurs, and no stresses develop in the steel.

In brazing three nipples on a formed sheet metal container the brazed joints were required to be leakproof under considerable pressure. The two nipples on the top were simultaneously brazed in 7 seconds, while the bottom one took 5 seconds. Use of preformed brazing alloy rings reduced the procedure to fluxing the parts, assembling them, and brazing. Overall rate of production could be increased 500-600 percent without the use of additional labor.

When a spline was brazed to a hub an assembly equally as strong as a machined part was achieved, thus saving time and material. Preformed alloy rings were ⅜ in. to ¾ in. silver solder and brazing time was only 12 seconds.

Starting motor armatures

High currents and speeds of starting motors demand that the joint between armature coil and commutator bars be of high conductivity and strength. An ordinary solder joint, however, is subjected to such high temperatures there is danger of centrifugal force pulling the coil out of the commutator slot.

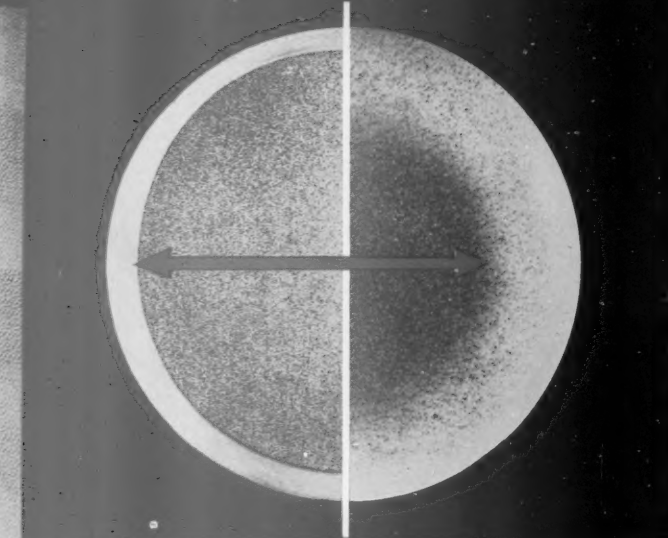
Silver solder is ideal since its electrical resistance is almost as low as copper and its tensile and shear strengths greatly exceed that of soft solder. It needs, however, a temperature of 1175 degrees F to melt it and cause it to flow. With ordinary brazing methods the copper of the armature coil and commutator conducts the heat away, necessitating long-time heating of the joint area. As a result of such heating, insulation between commutator bars is sometimes sufficiently damaged to cause short circuits.



CROSS-SECTION of rocker-arm adjustment screw shows the ball end hardened without any distortion of threads.

simultaneously took 6-7 seconds, the bottom nipple needed 6 seconds, and the seam between the upper and lower portions took 10 to 12 seconds, making an actual brazing time of 22-25 seconds.

When all other work-handling time requirements were added, an increased production rate of 40-50 mixing chambers



CONTROLLED HEATING of king pin gives thin, hardened surface with a ductile core (left micro-photograph section) while conventional methods let heat penetrate into core (right) to make contact brittle and weak.

Induction heating confined heat to the specific joint area without prolonged or excessive treatment. The armatures with flux and silver solder in place were mounted in a jig and brazed one segment at a time, with approximately 15-20 seconds needed for each braze. Results showed the armatures better both electrically and mechanically.

Plans for increased production by a company manufacturing tire pumps were delayed when their facilities for topping the pumps' cast iron bases and threading the sheet steel cylinders were found inadequate. By installing a 20 kw induction heater, fluxing pump bases and cylinders, assembling units with rings of solder internally placed, and soldering in groups of six, a mass production line which solders units in $1\frac{1}{2}$ to 2 seconds time can be achieved.

Melting and preforging

Small batch rapid melting of metals is yet another field where induction heating is being applied. The ability to melt small batches rapidly and conveniently with a minimum of dust, dirt, and radiation to surroundings is a distinct advantage.

Manpower and time saving are the factors to be considered when discussing preforging heating. With proper controls, billets can be so regulated that they are at the proper temperature when they reach the forge. Units for induction heating are also so space-saving that they can frequently be mounted in the most convenient location with respect to the presses, reducing handling and heat loss as work is transferred to the presses from the furnace.

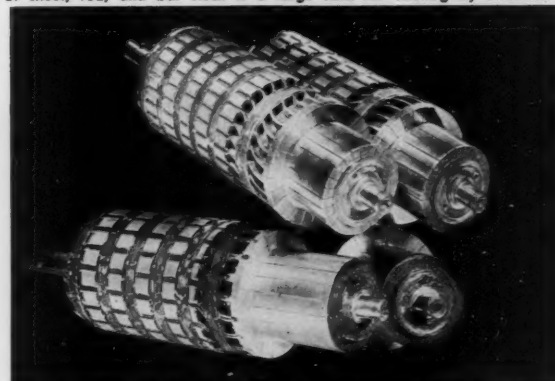
These applications of electrically induced heating are but a few of the many hundreds of products which can be brazed, soldered, annealed, hardened, melted or preheated for other metal processes. Metal working plants are building special laboratory and production facilities to conduct induction heating operations. Electrical utilities are assuming the responsibility for informing power users of developments in new equipment and possibilities of new applications.

Possible advantages to manufacturers are increased almost daily through the experiments and field experience of engineering and research staffs.

Allis-Chalmers Electrical Review • December, 1945



THREADED END of a pinion shaft is annealed to remove hard spots and to relieve any stress set up during machining and heat treating. Annealing of sheet, rod, and bar stock is a large field for heating by induction.

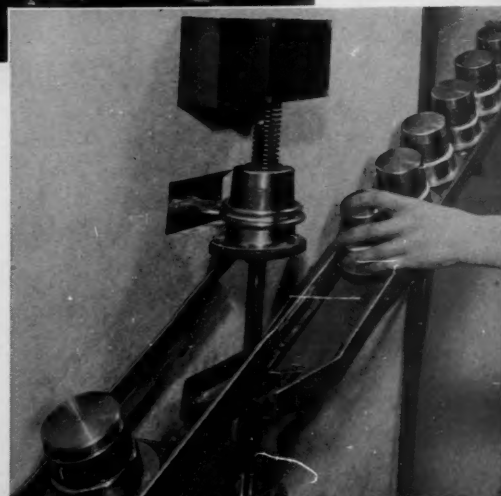


STARTING MOTOR ARMATURES have proved to be better, both electrically and mechanically, when joints between armature coil and commutator bars are brazed by induction heating. Segments, brazed one at a time, require 15-20 seconds each.



LESS than 10 seconds brazes water jacket to diesel engine cylinder.

BOMB FUSE adaptors are brazed at the rate of 250 an hour.





MODERN CALIFORNIA ARCHITECTURE of Burbank's new outdoor station blends in well with the surrounding residential area. Plant design meets

California's building code for earthquake protection economically, by avoiding usual top-heavy power-plant construction. (FIG. 1)

Burbank's Test

WHEN traditional design of a major capital goods item does not square with all requirements of engineering economics, a new design can open a profitable road to a new standard of appearance

J. H. McCAMBRIDGE

General Manager of Public Service Dept.
City of Burbank, California

SINCE it started producing kilowatts out in the California sunshine in 1941, the City of Burbank's outdoor power station has continually provoked questions among engineers who are chiefly acquainted with conventional type power plant design. The facts about four years of successful operation of this unique plant are likely, therefore, to serve as the basis for some further progressive power plant thinking.

Burbank's power plant venture has been a success largely because the problems which prompted the selection of the outdoor design have been solved in actual operation of the station. The conditions considered favorable to outdoor construction in 1939 were:

- 1—Avoidance of the increased cost that a conventional high and top-heavy station would have made necessary

in order to pass California's rigid regulations governing structures to resist earth shock and consequent high seismic moment.

- 2—California weather from May to October, being free from rain, provides a six-month period amply suitable for planned major overhaul operations on outdoor equipment.
- 3—Modern California architecture could be more closely realized with the outdoor design, making the plant harmonious with its location near the center of the city, on a well-traveled boulevard, surrounded by private residences and commercial establishments.
- 4—Stability and reliability necessary for any power station could be attained as well with outdoor construction as with conventional construction.
- 5—Fuel would be natural gas and oil, thus eliminating coal storage and handling systems which are such conspicuous parts of the conventional power plant.

The advantages of each of these has contributed to the highly satisfactory operation of the Burbank station.

Design for earth shock

An innovation in crane design which outdoor construction permitted meets California's requirements for structures to resist seismic forces. A cantilever type gantry crane on depressed runway tracks runs alongside the Burbank turbine deck,

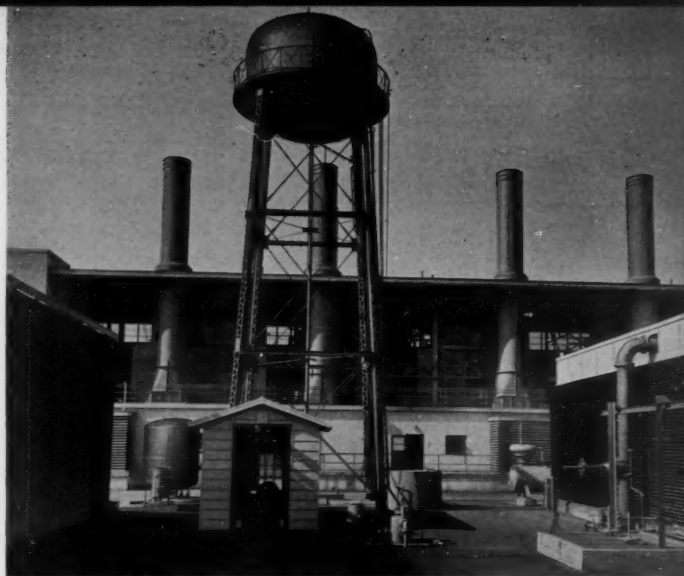
eliminating entirely the need for heavy elevated crane tracks, the most top-heavy feature of conventional design stations.

Superstructure over the boiler room and control rooms adjacent to the turbines costs no more than usual. In fact, due to mild California weather, it was practical to complete the outdoor plant idea by leaving one side of the boiler room open, protected only by an extension of the roof to canopy the open side. The first floor of the entire plant is walled, enclosing condenser, auxiliaries and lower parts of the boilers. Beyond the open side of the boiler room, cooling tower structures, necessary at Burbank because of absence of a water source, are arranged to blend with the general architecture. On the other side of the plant adjacent to the gantry crane tracks, a conventional outdoor transformer and circuit breaker station is installed.

Weather permits outdoor deck

Outdoor construction with a view to reducing building costs alone would not have been practical except for other reasons, most important being Burbank's rainless six months from May to October each year. During this period major overhauls are scheduled.

Easily accessible, the two 10,000 kilowatt turbines are installed in individual steel cab-like housings which are designed to leave room around the turbine for the normal operating activities. These cabs are insulated against seasonal



BOILER ROOM has one side open with canopy to protect men and equipment from rain and sun. Cooling towers are of modern design. (FIG. 2)

very best materials were used both in the main structure and in the architectural finish, and the final result was achieved without any appreciable increase in cost over any type of building which might have been constructed regardless of appearance.

A distinct contrast with most big city stations, the appear-

Tube Power Plant

temperature changes (as well as noise) by two inches of cork composition inside the steel walls. The outdoor turbine deck is of concrete slab construction, and it was later realized that water seals in all the slab joints would have precluded the possibility of cracks in the slab structure and leakage to the lower floor.

Removal of bearing caps and minor repairs are accomplished within the enclosure. For major overhauls the cab roof is lifted off by the gantry crane. The large turbine parts such as cylinder cover, steam valves and steam chest parts, governors, etc., can then be lifted out of the housing and deposited on the turbine deck or on a truck in the crane way.

Even during the rainy season, it is possible to make necessary repairs. For example, an accident in December, 1943, required 40 days or so of shutdown time. While repairs were being made, canvas awnings were erected and suspended over the turbine deck adjacent to the turbine cab. During lifting or lowering of parts it was necessary to remove the awnings. This required favorable weather, for unfavorable conditions, such as high winds, would cause extra trouble. During overhauls it is also necessary to protect removed parts from hot rays of the sun, to prevent serious expansion of parts.

Achievement of California architecture, readily apparent in the accompanying photos, was easily accomplished with the outdoor design, although when the plant was first proposed in 1939 there was some objection to it from Burbank's residents. However, in the architectural development of the plant, the

ance of Burbank's good-looking plant is so important because it is centrally located on a well-traveled boulevard and surrounded by private residences and commercial establishments. Even in this environment it detracts in no way from the beauty of its surroundings.

Handled ever-increasing load

From the modern, fluorescent-lighted, neat control room, located off the front end of the turbine deck at the Burbank station, the operator must not only control his 10,000 kw units, but also draw an allotted 5,109 kw from Boulder Dam through the Los Angeles line connections. Arranged for 15 years ago when the total load at Burbank (see chart) was less than half that much, this allotment had to be paid for whether used or not.

It was shortly after, however, when the aircraft industry expanded and growth of the aircraft factories established at Burbank, created a heavy, growing, industrial power load. Just a few months before Pearl Harbor, the first Allis-Chalmers 10,000 kw unit was installed, and the second was put on the line in July, 1943, making the total capacity 25,109 kw at that time. When the first 10,000 kw indoor type turbine was purchased, the load prediction indicated that the peak would be 7,000 kw and the unit was designed on that basis. Before construction was completed, however, the peak had already exceeded 10,000 kw, so the second unit was designed for maximum economy at 10,000 kw.

Peak demand for the season 1944-45 reached 35,000 kw, representing a 1000 percent increase in load in ten years. This was handled through interconnections under WPB's Pacific Southwest Power Pool¹ and "surplus power" from Boulder Dam by special agreement with the City of Los Angeles.

Type of turbine units

The two 10,000 kw steam turbines of the generating units were designed for steam conditions of 600 lbs. gauge throttle pressure, 825° F. throttle temperature and 2 inches Hg. absolute exhaust pressure. The generators were designed to operate at 3 phase, 60 cycles, 4500 volts and 0.8 power factor. Each unit is provided with a 250 volt, 60 kw direct-connected exciter and a 125 volt, 3.5 kw pilot exciter. Since both the generators and the exciters were completely weather-proofed, the steel cab-like housings covered only the turbines and the bearing pedestal between the turbines and the generators. In keeping with the general design of the power station, these housings were streamlined, ventilated, and provided with access doors.

The turbines are of the impulse-reaction type with solid-forged turbine spindles. The generator rotors and exciter rotors as well as the turbine spindles are each carried in two pressure-lubricated bearings.

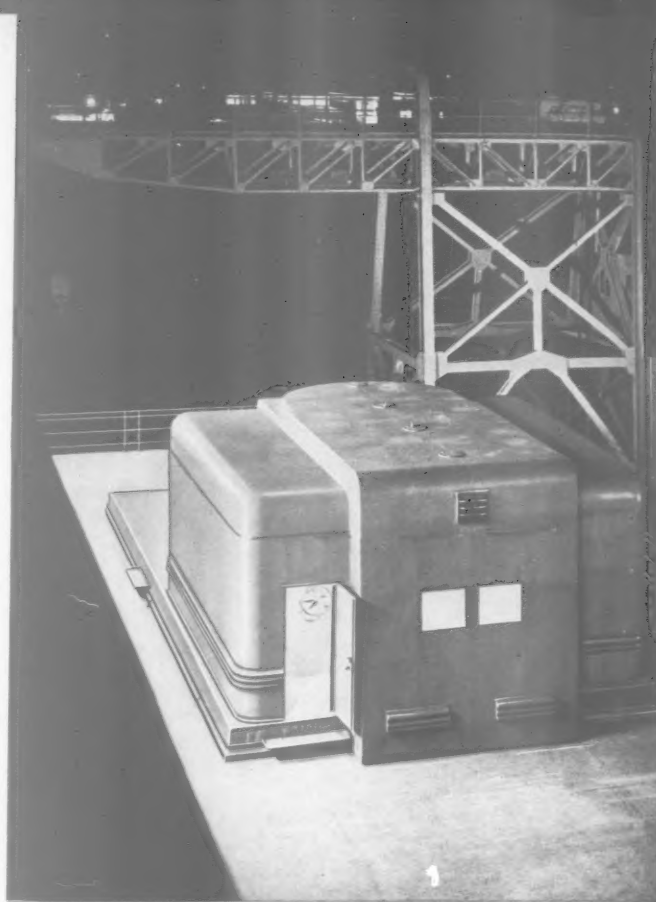
For feedwater heating purposes each turbine is provided with four extraction nozzles in the lower half of the turbine casing. These extraction nozzles supply steam to four closed heaters and an evaporator. The arrangement of the feedwater heating cycle is such that approximately equal temperature rise is obtained in each heater with a final feedwater temperature of 376° F. at 10,000 kw load. On the No. 1 turbine unit, blading proportions were selected to give the best heat consumption operating extracting with a load of 7500 kw. Due to the growth in load demand, the blading proportions on the No. 2 turbine unit were changed to give the best heat consumption operating extracting with a load of 10,000 kw. Both turbine units are capable of carrying 12,500 kw continuously at unity power factor.

Due to possible necessity for taking on load instantly, the turbine governors are of the double oil relay type capable of holding the turbine speed within 2 percent of normal with an instantaneous load change from 2500 kw to 10,000 kw. As a safety feature with this type of operation, the governor is equipped with a load limiting device which may be set and locked to limit the load at any desired maximum. Below this maximum load the governor functions in a normal manner.

Both turbine-generating units are equipped with conventional accessories, such as centrifugal oil purifier, 80° F. generator air cooler, generator temperature indicating instrument, and rocking contact type voltage regulator.

In addition to balancing the load between hydro and steam power, the Burbank operator must also take advantage of cheap natural gas fuel during certain months of the year

¹THE PACIFIC SOUTHWEST POWER INTERCHANGE COMMITTEE, formed in 1942 at WPB suggestion, made it possible for management representatives assisted by operating engineers of public and private power systems in California, southern Nevada, and Arizona to reduce to a minimum the installation of new generating units by use of relatively inexpensive tie lines between both 60 and 50 cycle systems and by coordination of overhaul and maintenance schedules. As the war progressed, the Committee also conserved fuel oil by effective summer use of natural gas and winter use of stored hydro power, leaving oil for only the largest and most efficient generating units in the pool. Both participants and WPB were very well satisfied with the pool's accomplishments.



CANTILEVER GANTRY CRANE traveling in a depressed runway eliminates problem of overhead crane tracks. For major repairs, entire cab roof is simply removed. Minor repairs can be handled inside of cab. (FIG. 3)

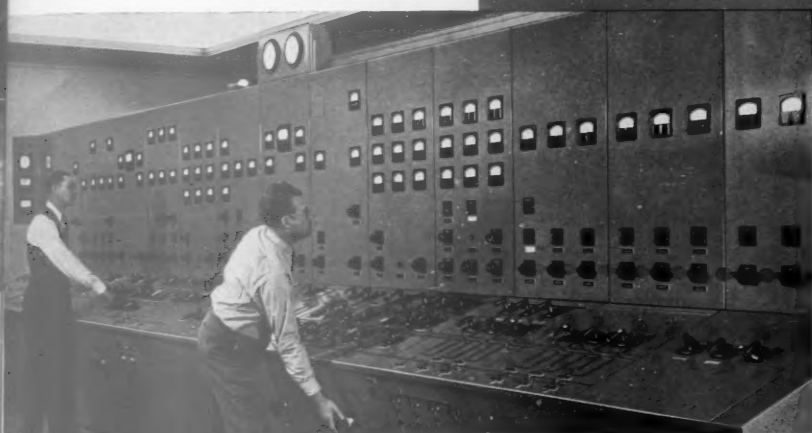
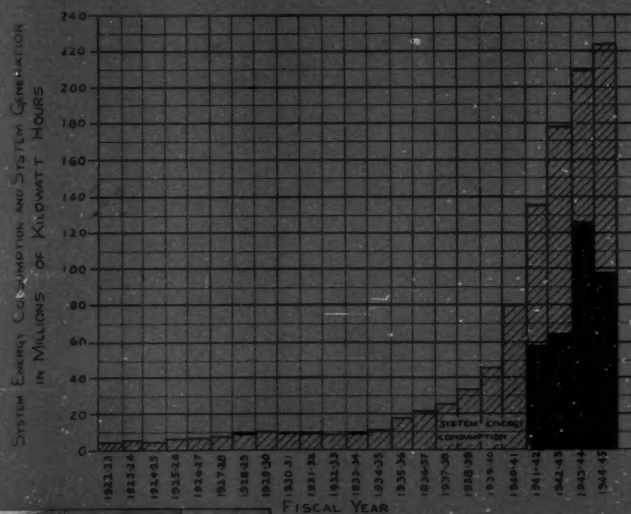
when domestic consumption of gas is small. The remainder of the time fuel oil must be used at higher fuel cost. Use of these fuels eliminated all coal handling and storage facilities, a conspicuous part of conventional steam stations.

The maximum of Boulder Dam power is obtained at all times by the tele-metering communication between the control room and the principal 34.5 kw substations. It is accomplished automatically by combining this equipment with the other control equipment.

Each Burbank generator is connected by means of a cable system to a 4500 volt grounded neutral distribution bus. Generating at the same voltage as the distribution voltage on a grounded neutral system requires special protection. Lightning arresters and capacitors are installed as close as possible to the generator terminals to provide adequate surge protection to the generator windings.

The City of Burbank is proud of these power plant facilities which have served at peak capacity with such great success through the hectic war period. And, in spite of an anticipated decline in load for a few coming years, new manufacturing industries and increased use of domestic appliances are counted on to build up the load that soon again will fully utilize the community's pioneer station.

ACUTE POWER PROBLEM facing Burbank since Pearl Harbor is shown clearly in this chart. Tie-in with Southwest Power Pool provided for excess power requirements. (FIG. 4)



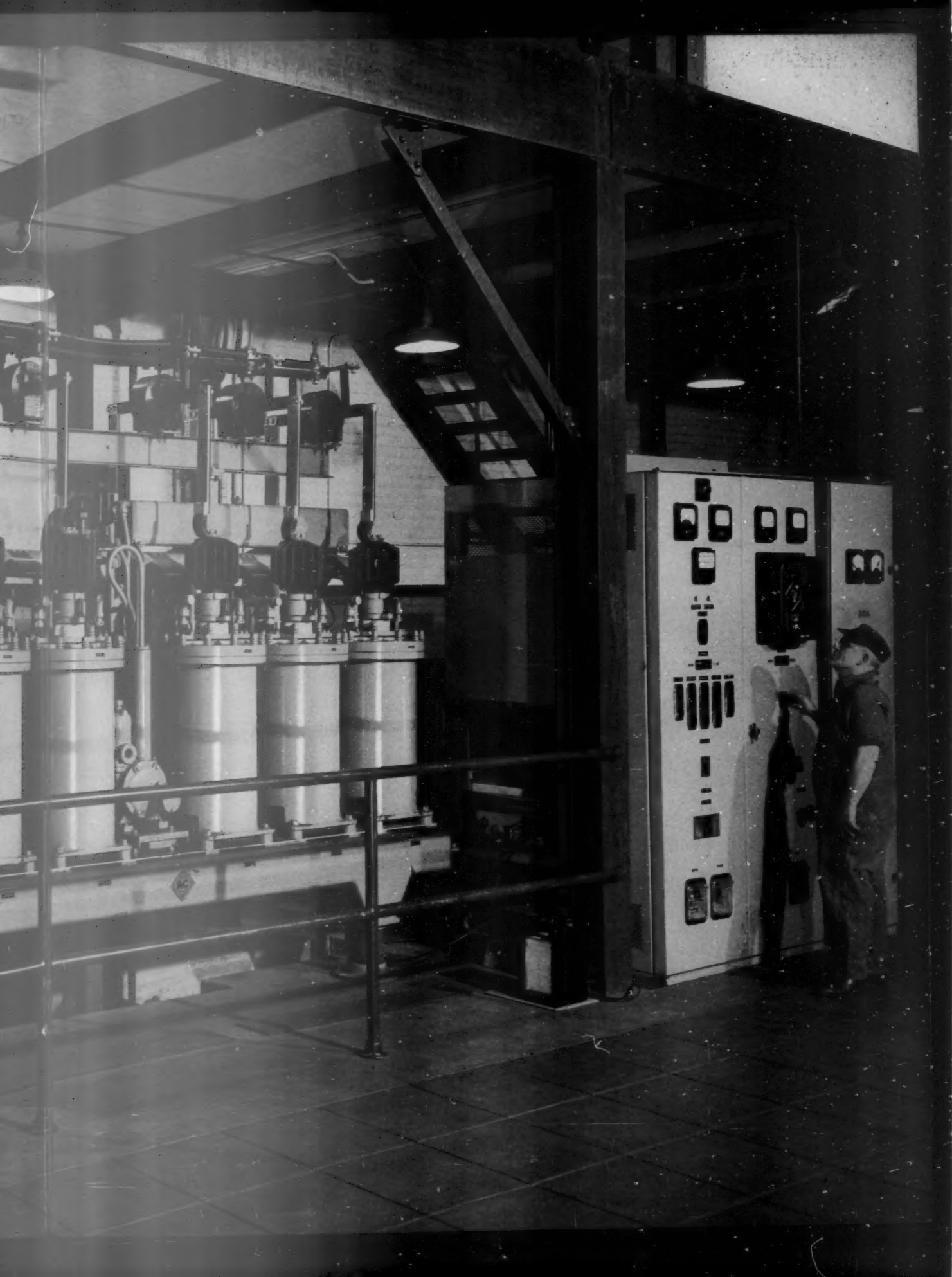
MODERN TREATMENT OF PLANT DESIGN is carried through to this efficient control room. Dispatcher is in constant touch with power pool headquarters. (FIG. 5)

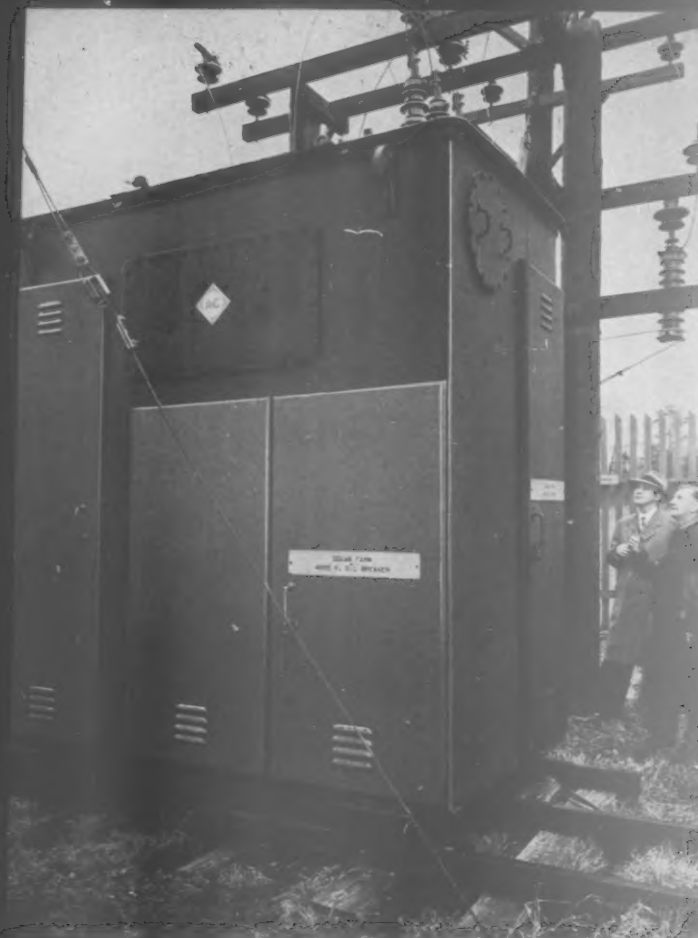
D-C POWER FOR BASIC STEEL PLANT (as shown on following pages) is supplied by 1000 kw, 12-tank Excitron type mercury arc rectifier, which converts 6900 volt, 3 phase, 60 cycle electrical supply to 250 volts. Serving all general mill requirements, the unit delivers power for rolling mill, cranes, hoists, motors.

CAB INTERIOR is well lighted providing easy access for regular inspection. Sound deadening in cab walls cuts noise. (FIG. 6)

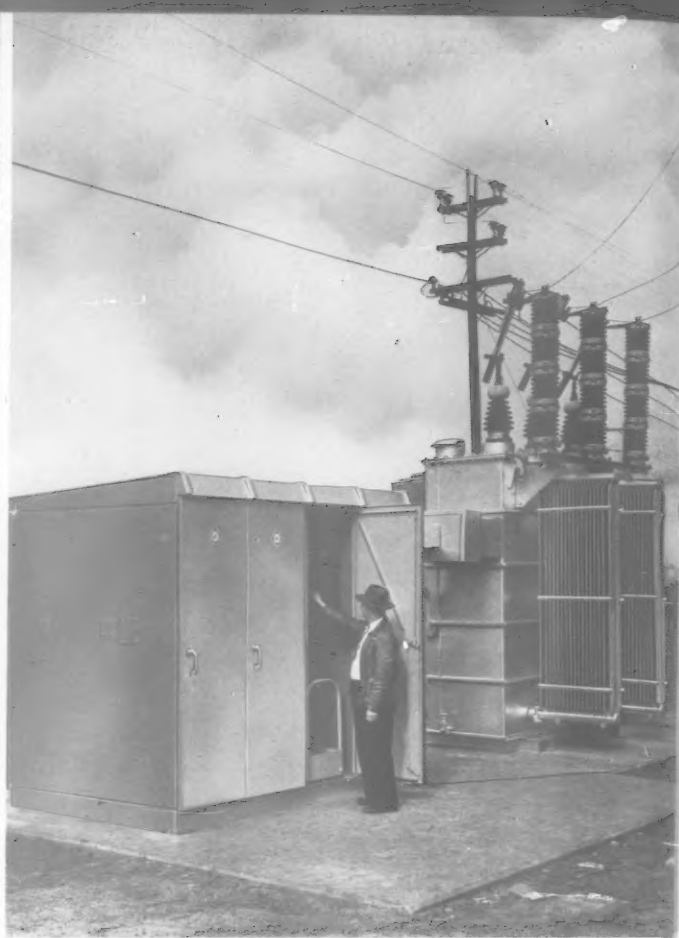








SINGLE CIRCUIT UNIT SUBSTATION such as this 1500 kva unit (primary voltage is 33 kv, secondary 2300 v) serving a large hospital in rural Pennsylvania has become standard equipment for many utilities. (FIG. 1)



LIGHTNING ARRESTERS and high voltage fuses are easily mounted on multiple circuit substations such as this 1500 kva unit at a large southern arsenal. Primary 44 kv, secondary 2400 volts. (FIG. 2)

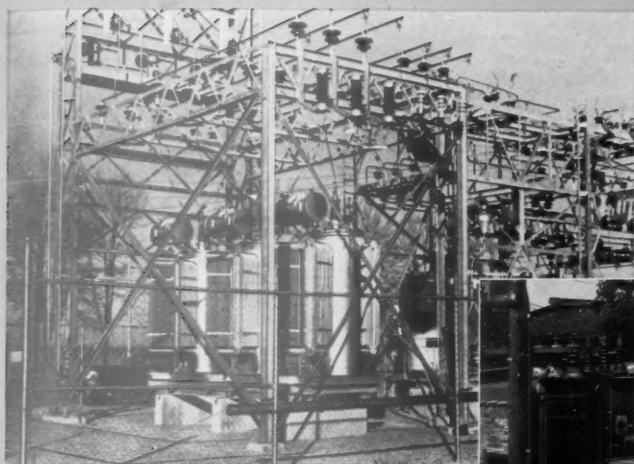
STANDARDIZATION SPEED-UP SIMPLIFIES

Substation Engineering

**SINGLE-CIRCUIT, multi-circuit,
and load center unit substations
have grown to full maturity
in just six years**

J. N. BANKY

Mixed Apparatus Division, Allis-Chalmers Mfg. Co.



DOUBLE-ENDED MULTIPLE CIRCUIT substations such as unit shown provide maximum of dependability for utilities. Load can be carried from either end. Transfer switches are interlocked, automatically operated. (FIG. 4)

MODERN SITE-CONSTRUCTED SUBSTATIONS such as this 3000 kva bank are gradually being replaced by unit subs, because of unified responsibility of a single manufacturer and elimination of expensive installation. Unit in Fig. 7 has same kva rating with higher primary voltage. (FIG. 3)



A UNIT SUBSTATION, as the name implies, is essentially a complete substation, including switchgear, transformer, and metering equipment built as a unit or series of interconnected units and enclosed in matched steel cabinets.

Made on a custom-built basis for a few pioneer utilities just before the war, the unit substation has developed into an accepted and highly developed piece of electrical apparatus. As reconversion enters the picture, it becomes important to analyze these developments and understand the classification of standard units and their application.

Unquestionably the war did hasten the development of unit substations, but their obvious advantages would certainly have insured their acceptance eventually without the impetus of war. Nevertheless as a nation at peace we can look back over the trends in application of these units and outline their definite though hastily chosen standards.

When all available spare equipment was pressed into service at the time of Pearl Harbor, the high cost of non-standard electrical components became painfully obvious. Odd size transformers or switchgear lay idle waiting to be rewound or rebuilt while war plants and utilities only a few miles away were desperately in need of this same apparatus, but with a different rating. Any used electrical equipment dealer knows well the low resale value of odd-rating transformers.

With the war placing these facts before users and manufacturers more clearly than ever before, requests for odd or unusual design units dropped to a minimum. Thus in a

single circuit substation as outlined here, after the original engineering design had been made, units were chosen as needed, standard optional equipment was added easily at the factory, or some of it later in the field. Parts clearances and electrical ratings of all components were interchangeable, ending the need for a large stock of repair parts. War-born simplifications have become peacetime standards.

Three distinct types of unit subs have emerged in the past six years, and all future substations (other than mobile units) will probably fall into one of these classes: single circuit, multiple circuit and load center unit substation. The Application Chart on page 22 contains practically all of the basic application standards on these unit substation types as they exist to date.

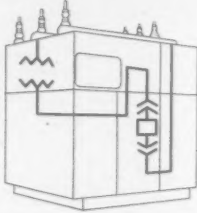
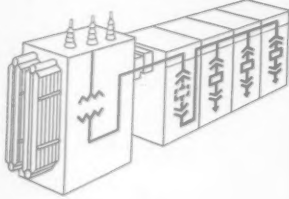
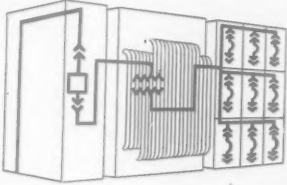
Single circuit unit substation

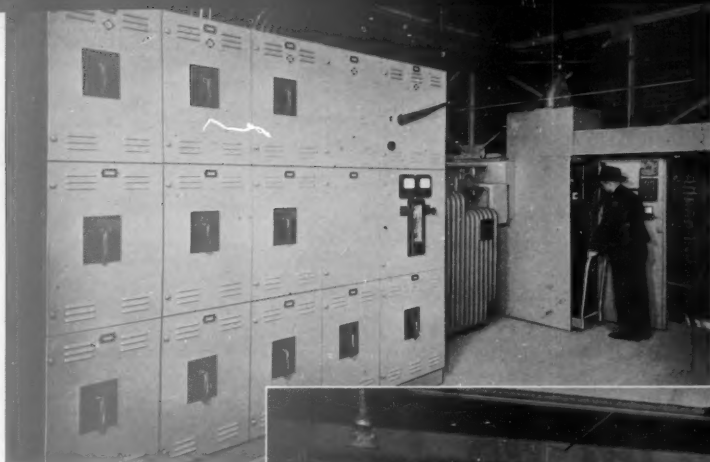
The single circuit substation consists basically of a three-phase transformer with one secondary breaker integrally mounted in one metal-enclosed packaged unit. The standard instrument transformers and meters are included inside the cabinet with the breaker. Hinged, locked doors and removable panels provide a maximum of safety with easy inspection and maintenance of equipment. Figure 1 shows a typical single circuit substation.

This unit substation is used to step down subtransmission voltages to distribution voltages of 5000 volts and below where only one secondary feeder is required. A unit substation of this type is readily applied to feed a 5000 volt utility distribution loop which has sectionalizing breakers.

UNIT SUBSTATION APPLICATION CHART

A QUICK REFERENCE CHART SHOWING STANDARD AND NORMAL OPTIONAL EQUIPMENT IN MODERN UNIT SUB DESIGN. OTHER OPTIONAL EQUIPMENT MAY BE ADDED BUT WILL REQUIRE SPECIAL ENGINEERING.

	SINGLE CIRCUIT SUBSTATION	MULTIPLE CIRCUIT SUBSTATION	LOAD CENTER SUBSTATION
			
COMPONENTS	<p>In one metal-enclosed package unit</p> <ul style="list-style-type: none"> Three-phase transformer Secondary breaker Instrument transformers Meters Relays <p>Standard connections</p> <ul style="list-style-type: none"> High voltage bushings Low voltage bushings <p>Normal optional equipment</p> <ul style="list-style-type: none"> Cable connections "A" frame Cover-mounted fuses Lightning arresters 	<p>Three-phase transformer throat-connected to:</p> <ul style="list-style-type: none"> Two or more steel-enclosed units, each containing: Vertical lift switchgear units complete with instrument transformers, Meters and relays <p>Normal optional equipment</p> <ul style="list-style-type: none"> Primary fuses (cover-mounted) Lightning arresters Primary cable connection Double-ended transformer arrangement 	<p>Three-phase transformer (indoor or outdoor) throat-connected to:</p> <ul style="list-style-type: none"> Two or more steel-enclosed units, each containing: Low voltage switchgear with manually-operated drawout type air breakers <p>Normal optional equipment</p> <ul style="list-style-type: none"> Primary circuit breaker or Primary fuses and disconnect switch Main secondary breaker Electrically operated breakers
APPLICATIONS AND USERS	<p>To reduce transmission voltages to 5 kv or less where only one secondary feeder is required</p> <p>Small municipalities</p> <p>Additional substation (Temporary or permanent)</p> <p>Small industrial loads</p> <p>Small emergency loads</p>	<p>To handle loads at 2400 volts to 15 kv where a number of secondary feeders are required</p> <p>Standard industrial or residential substations</p> <p>Distribution loops</p>	<p>To serve a number of loads 600 volts or less indoors or out from a high voltage feeder</p> <p>To serve small power and lighting loads below 600 volts near center of load</p> <p>Factory or industrial centers of load (motors, lighting or power)</p>
RATINGS	<p>CAPACITY</p> <p>Standard — 1000 kva to 5000 kva</p> <p>Special — 300 kva up</p>	<p>CAPACITY</p> <p>Standard — 1000 kva up (limited by secondary breaker size)</p>	<p>CAPACITY</p> <p>Standard — 100 kva to 2000 kva</p>
	<p>VOLTAGE RATINGS</p> <p>Primary — 13.2 kv to 66 kv</p> <p>Secondary — Below 5 kv</p>	<p>VOLTAGE RATINGS</p> <p>Primary — 12 kv and up</p> <p>Secondary — 13.2 kv to 2.4 kv</p>	<p>VOLTAGE RATINGS</p> <p>Primary — 2400 volts to 15 kv</p> <p>Secondary — Below 600 volts</p>
TRANSFORMER EQUIPMENT	<p>(Oil Cooled)</p> <p>NORMAL OPTIONAL FEATURES</p> <p>Load tap changer</p> <p>Forced-air cooling (automatic or manual)</p> <p>Thermal relay</p> <p>Delta-wye terminal boards</p>	<p>(Oil Cooled)</p> <p>NORMAL OPTIONAL FEATURES</p> <p>Same as single circuit substation</p> <p>Dry type transformer (For inside use below 15 kv primary)</p>	<p>(Non-Inflammable Liquid Cooled or Dry Type)</p> <p>NORMAL OPTIONAL FEATURES</p> <p>Forced-air cooling for liquid-cooled transformers (automatic or manual)</p> <p>Thermal relay</p> <p>Delta-wye terminal boards</p>
BREAKER EQUIPMENT	<p>PRIMARY</p> <p>None</p>	<p>PRIMARY</p> <p>Breakers optional (for 15 kv and below only)</p>	<p>PRIMARY</p> <p>(Air or oil circuit breaker)</p> <p>Disconnect switch (with or without fuses)</p>
	<p>SECONDARY</p> <p>Electrically-operated vertical lift</p> <p>50,000 to 250,000 kva breaker ratings (air or oil type)</p> <p>(Switchgear has facilities for all standard metering and instruments)</p>	<p>SECONDARY</p> <p>Same as single circuit substation (main secondary breaker often added)</p>	<p>SECONDARY</p> <p>Manually or electrically-operated drawout air breakers</p> <p>15,000, 25,000, 50,000, 75,000, or 100,000 amps</p>
	<p>OPTIONAL</p> <p>None</p>	<p>OPTIONAL</p> <p>None</p>	<p>OPTIONAL</p> <p>Secondary metering equipment</p>



VERTICAL-LIFT SWITCHGEAR, metal-clad, facilitates regular inspection on this 500 kva load center unit substation. (FIG. 6)



LOAD CENTER UNIT SUBSTATION in this midwest plant is connected to the shop distribution circuit. A 150,000 kva vertical lift breaker provides individual substation protection. Transformer is non-inflammable liquid cooled, eliminating fire hazard. (FIG. 5)

Public utilities have found particular use for this substation to bring relief to lines temporarily overloaded. Subtransmission voltages can be used for longer runs and reduced near the load itself, doing away with low voltages caused by excessively long, low voltage lines.

The standard kva ratings of this substation are from 1000 kva to 5000 kva. Special kva ratings have been built, however, from 3000 kva and up, as shown on the accompanying chart.

The three-phase transformer is built with or without tap changing under load equipment. Taps for no load tap changing are considered standard. Below 2000 kva and 46,000 volts, the sealed type of tank construction is usually used. Above this kva rating and voltage, inert gas equipment is provided. Such items as provisions for future forced air cooling, automatically controlled fans, delta-wye terminal board, lightning arresters, etc., are included as required.

The circuit breakers in the single circuit unit substation are electrically operated. Standard switchgear accessories include current transformers, overcurrent relays, necessary potential transformers, together with ammeters and voltmeters. All the metering equipment similar to that supplied on standard metal clad switchgear is usually included. Automatic reclosing relays, together with necessary control relays are part of the standard accessories for single circuit substations.

Multiple circuit unit sub

The multiple circuit unit substation has become standard where transmission voltages are to be stepped down and fed through switchgear to a number of feeders. Utilities have found such a unit ideal as package equipment for industrial or heavy residential loads. Feeders are often tied in with adjacent substations through distribution loops.

The top primary voltage rating usually considered feasible on unit substation is 66,000 volts although some recent installations have been completely successful at 110,000 volts primary voltage. Above 33,000 volts roof bushings are used on all substations. Below this value either cable terminators or roof bushings can be used.

Switchgear for the individual feeders, each housed in its own matched cabinet is similar to that of single circuit subs, including connections for kva demand metering, watt-hour meters, etc. In addition, a main secondary breaker is often included next to the transformer where a utility desires to tie two or more multiple circuit subs together through a closed or open loop for greater reliability of service.

Multi-circuit substations, although generally considered an outdoor installation, have been built for indoor use with complete satisfaction where the primary voltage is less than 15,000

volts. Figure 4 illustrates a unit of this type often utilized where a heavy concentration of 2300 v feeders is required at some distance from outdoors.

Load center unit substation

The most popular type of installation has been the load center unit substation, since it provides the answer to the problem faced by almost every industrial plant—that of supplying a number of heavy low voltage loads from a high voltage source near the center of load.

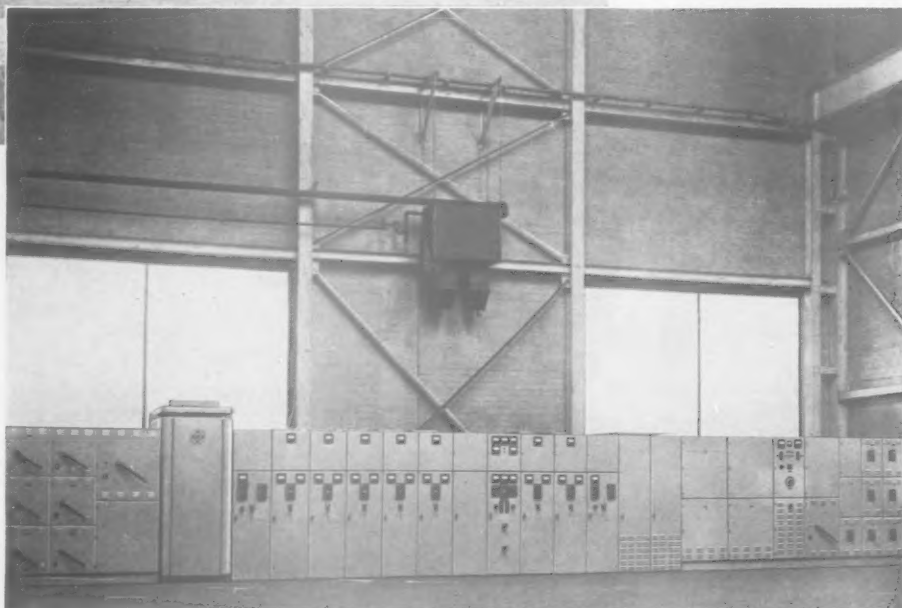
Long runs of heavy cable are eliminated, breakers and automatic protection equipment are standardized and made interchangeable, while appearance, safety, and convenience are

greatly improved when a load center sub replaces the former array of switchboxes, breakers, fuses, and junction boxes spread throughout an area.

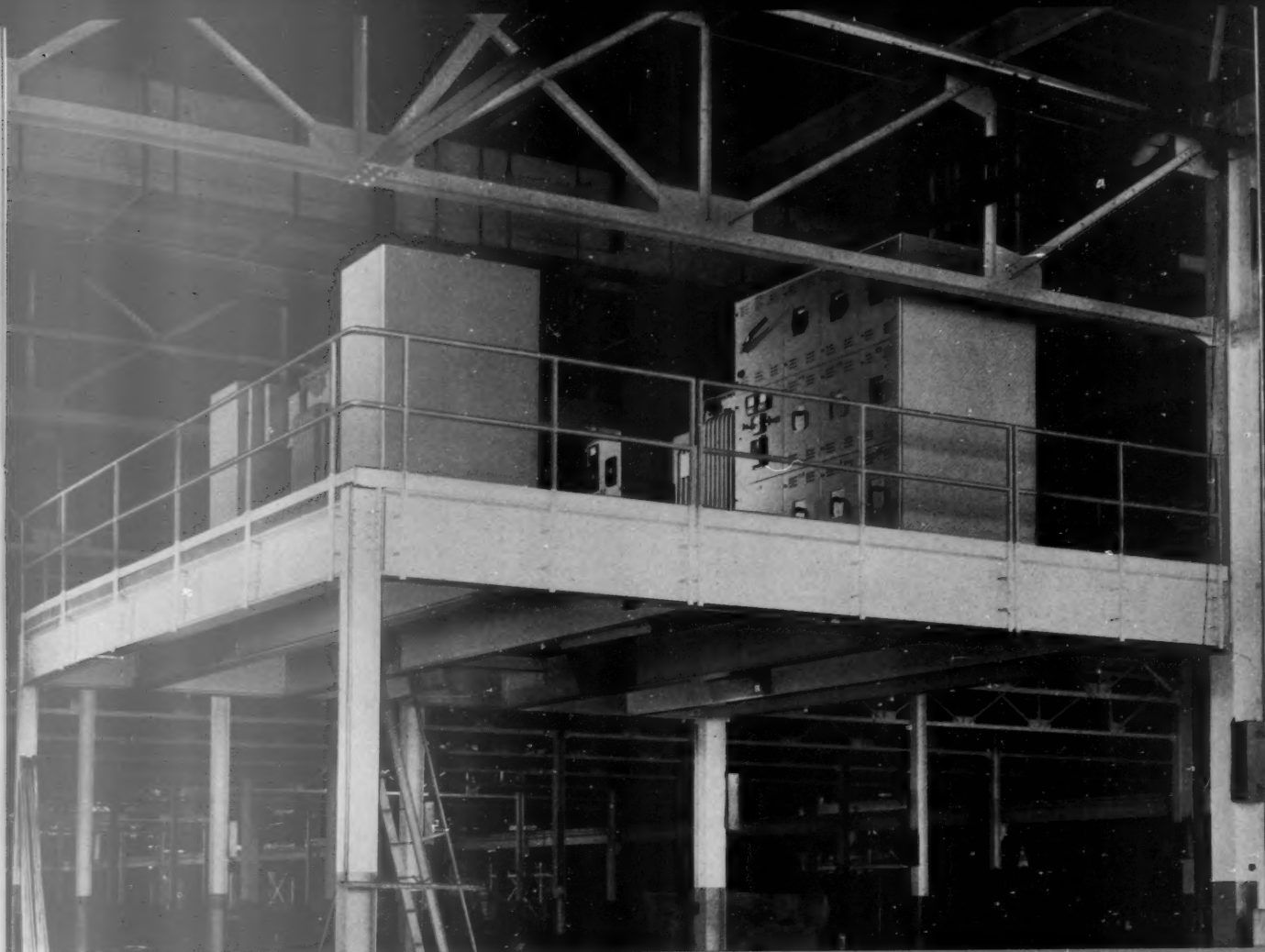
Unit substation equipment has come through the revolutionary stages that every well-engineered piece of electrical equipment must pass through. Its development has perhaps proceeded faster than many similar items due to war-born requirements. Standards and application limitations have been set to allow users the maximum of versatility, yet to allow designers and manufacturers to reduce special designs and spare part stock. This development early in its growth promises a highly successful future for unit substations in the electrical industry.



PLEASANT APPEARANCE and maximum safety are emphasized in multiple circuit sub installed in residential area by a midwest utility. Primary voltage 33 kv, secondary 4.33 kv. Weatherproof drop collar makes installation simple. (FIG. 7)

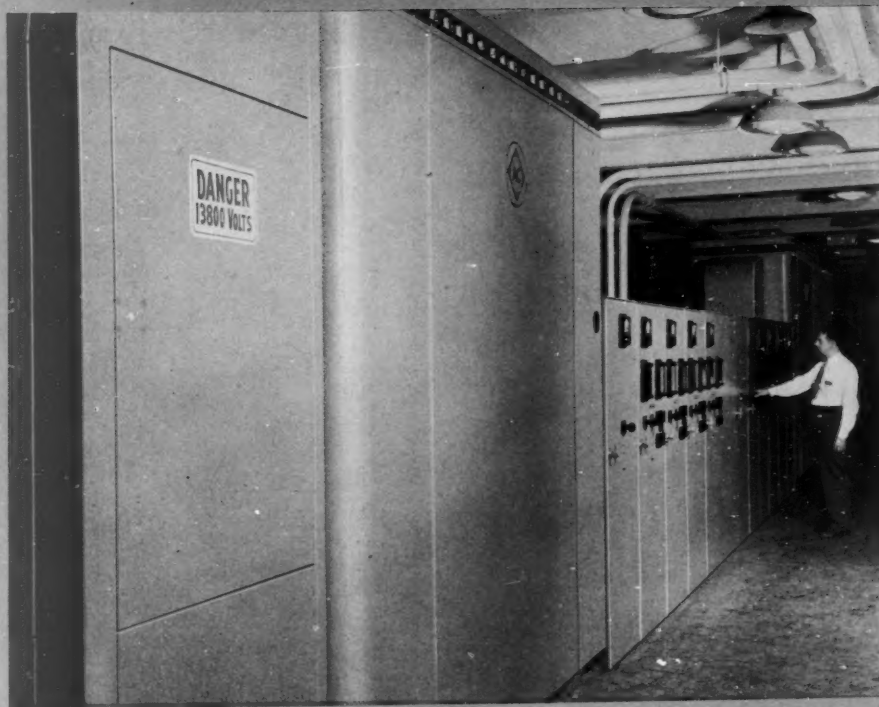


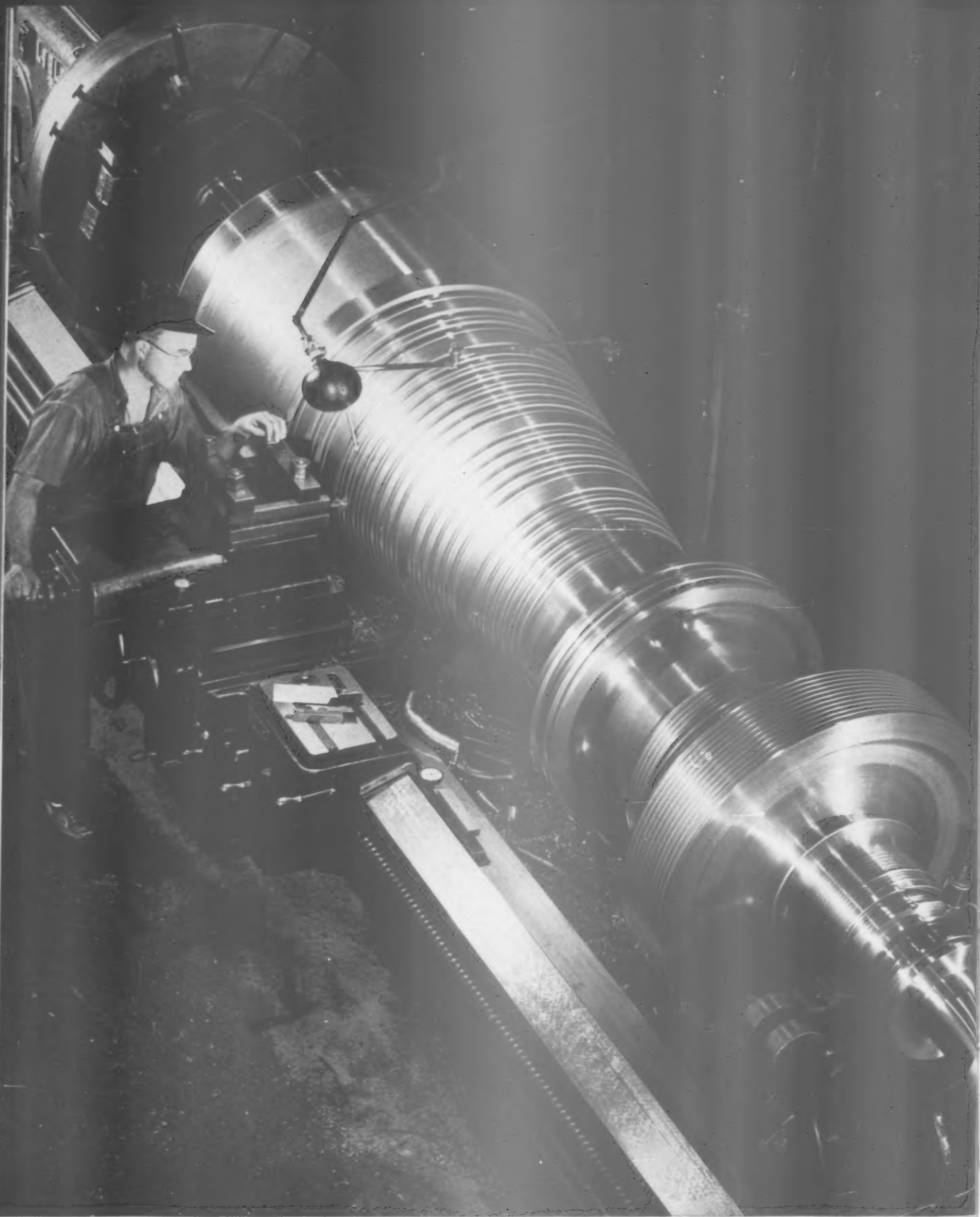
PACKAGED UNIT SUBSTATION of special design includes separate low volt panels for low voltage a-c, 2000 kva transformer, high voltage a-c, rectifier transformer, rectifier, and low voltage d-c, left to right. (FIG. 8)



LOAD CENTER UNIT SUB for power and lighting load can be balcony mounted to save valuable manufacturing space. (FIG. 9)

ONE OF MANY VARIATIONS available in unit sub installations is shown in this double-ended multiple circuit unit at a midwest rubber plant. Each transformer has main breaker feeding three 2300 volt air blast breaker cabinets. Entire sub can be fed from either end through center tie-in breaker cabinet. (FIG. 10).





SERRATED REACTION BLADE GROOVES in the spindle of a 20,000 kw, 3600 rpm, single cylinder, impulse reaction steam turbine are machined by a skilled lathe operator. Precision lathe work is also required on the journal, thrust collars, grooved surface for gland packing and grooves for balance piston packing and impulse blades.

Patents

AND RIGHTS TO INVENTIONS

ENGINEERS' interest in certain patent problems produces these answers to the most often asked questions

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THE comic strip standard selling price for a patent is \$1,000,000. Assuming the average cost of obtaining a patent to be \$500, this would represent a 2,000 to 1 return on the original investment. Few patents have been worth a million dollars, and a great percentage of the approximately 2,400,000 patents issued by the United States Patent Office have failed to provide a monetary return sufficient to defray the cost of obtaining the patent.

An invention often is made during the solution of a problem and starts with an idea for doing something new or doing something old in a new way, often without the inventor realizing that invention is involved. If and when the inventor realizes that he may have made an invention, the possibility of obtaining patent or other protection interests him.

Economics is a first consideration in determining the desirability of patent protection. Again assuming the cost of obtaining a patent to be \$500, will the right to exclude others from using the invention be worth \$500? The correct answer to this question involves consideration of the extent of the use of the invention during the possible protection period; that is, whether a great many or only a few uses would be made. A further consideration involves the necessity and cost of development of the invention so that it may be commercially successful and the ancillary question of necessity of development of a market. Another consideration involves the question of other ways of doing the same job—that is, whether there are other solutions for the problem; and if so, does this invention solve the problem in a cheaper, quicker, or better manner?

Exclusive rights to inventions

If the answers to the above questions lead to the decision that exclusive rights to the invention are worth more than the patent cost, steps should be taken to maintain these exclusive rights. Although the value of preventing others from using the invention may not seem to be worth the patent

cost, patent protection may still be desirable. The inventor may desire to establish his right to use his invention independently of any patent that another might obtain on a similar invention.

One method of maintaining exclusive rights to an invention is to keep the invention secret, the prevention of others from making or using the invention resulting from their lack of "know-how." However, this method is seldom effective for more than a very short period of time, and if and when someone else discovers the secret, the exclusive rights vanish.

The better and more usual method of providing exclusive rights is to obtain patent protection. First step in obtaining patent protection is to record the conception of the invention, preferably by writing a description of the device and its operation, illustrated by sketches if helpful, and by disclosing the invention to others. The description and the sketches should be signed, dated and witnessed, with the date of witnessing. And the next desirable step is to diligently complete the invention. Completing the invention, in the technical patent sense, is effected by reducing the invention to practice, and actual reduction to practice is effected by embodying the invention in a full size device and operating it successfully under conditions similar to those to which it would normally be subjected. The filing of a patent application including patentable subject matter is considered a constructive reduction to practice.

Patent application procedure

At any time after conception of the invention, the inventor will probably desire to consult his patent attorney. Few inventors have the technical knowledge necessary for the skillful preparation of a patent application, and unless the application is skillfully prepared the resulting patent may well lose some or all of its potential commercial value.

Before a patent application is filed, the patent attorney may make a search of the art to determine whether similar devices have been disclosed in previously granted patents or other publications, in order to determine whether the probable claims obtainable are worth the cost of the patent. The prior art also serves as a guide in drawing the patent claims.

After the patent application is filed, it is usually left in the hands of the attorney who prosecutes the application in the Patent Office until a patent is issued, or other final action given. If a patent issues, the inventor is granted exclusive rights for a period of 17 years beginning with the date the patent issues. A United States patent gives the inventor exclusive rights only for manufacture, use, and sale in the United States. If exclusive rights in other countries are desired, it is necessary to file patent applications in those countries also.

A valid patent can be obtained only if the patent application is filed within one year (two years for patent applications filed prior to August 5, 1940) from the date on which the invention was on sale, was put into public use or described in a patent or printed publication.

A valid patent can be obtained only by the "first" inventor. When two or more individuals independently conceive and complete the same invention, it is necessary to determine which one was "first." The first to complete the invention is presumed to be the first inventor. However, the matter of diligence between conception of the invention and its reduction to practice or completion may affect this presumption.

If a man who first conceived an invention stopped work on it for a period of time before completion and resumed work only after a later conceiver had completed the same invention, the later man may be determined in an interference proceeding in the Patent Office to be the "first" inventor so far as the right to a patent is concerned. If the first man could prove diligence in working toward completion of his invention, from a time just prior to the time the second man entered the field until completion of his (the first man's) invention, the first man would be determined to be the "first" inventor, unless he had abandoned his invention.

The issuance of the patent to an inventor gives him no further right, other than he then has, to use his invention. His right to make, use and sell his invention may be limited by prior patents issued to others. The issuance of a patent is no guarantee as to the validity of the claims therein, but the burden of proof is on one who disputes their validity. In other words, the claims of an issued patent are presumed to be valid until proved invalid. The claims of a patent appear in numbered paragraphs describing the forbidden ground on which others may not tread.

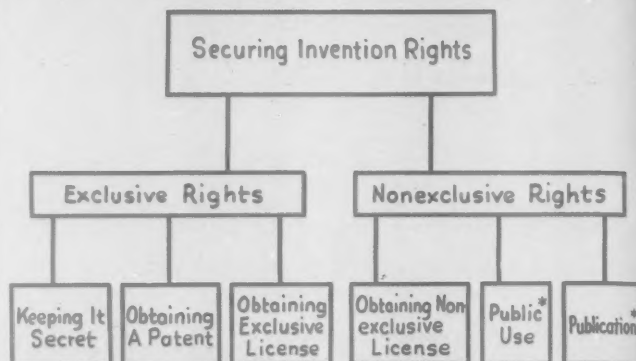
A patent owner may transfer rights to his patent by assignment or by granting the exclusive license with a right to sue for past infringement. After such assignment or exclusive license, his rights to make, use or sell apparatus embodying the invention are no greater than those of any other outsider. However, by granting a non-exclusive license, he gives up his right to prevent the licensee from manufacturing, using or selling the device covered by the patent. Such non-exclusive license may be limited to include only a particular class of devices or may be limited territorially. A patent owner may forfeit his right to recover from an infringer by knowingly permitting long-continued infringement of the patent by such infringer, without taking effective action toward stopping it.

Non-exclusive rights to inventions

Without filing a patent application an inventor may perpetuate the right which he then has to make, use and sell his invention by the doing of some act which will bar others from obtaining a valid patent for such invention. This may be accomplished in either of the following ways:

1. **Public Use**—If the invention is embodied in one or more installations in public use for one year before another files a patent application for such invention, no valid patent can be obtained, and hence such public use would preserve the non-exclusive right which the inventor has to make, use or sell his invention. Of course, such rights being non-exclusive, other persons may similarly make, use, and sell such invention.

2. **Publication**—If the work of embodying the invention in a public use is too great or costly, the same type of protection, as set forth in (1) above, can be obtained by publishing a disclosure of the invention. Such a publication more than one year prior to filing of a patent application would bar the grant of a valid patent for the invention. This published disclosure must be sufficiently clear and complete so that any one skilled in the art could make and use the invention. The publication must be a printed one and must be available to the public. In this connection, a publication by a manufacturer for distribution only within his own organization would not bar another inventor from obtaining a valid patent for the invention.



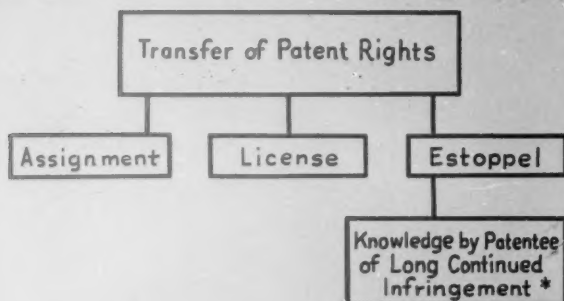
A situation sometimes arises in which one desires to use a structure which effects the same result as obtained by a patented invention, but to do so, without license, would invite a suit for infringement. In such cases, there are several courses open. One of the best ways out of this difficulty is to find a different way of doing the same thing; that is, a way which does not utilize the invention covered by the patent claims. Inventions are often made in this manner. The saying "Necessity is the mother of invention" applies. By the exercise of ingenuity, it is often possible to obtain the desired result in a different or better manner. On the other hand, often an older and patentably free device may be found to be equally good or to serve the purpose better.

Avoiding patent claims

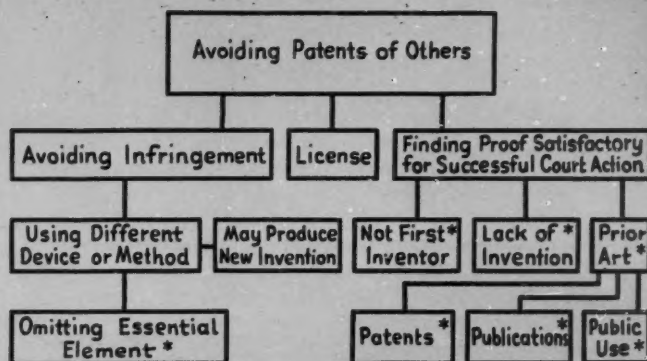
In the process of finding different ways to produce a given result, the principle of inversion is sometimes useful, particularly where the resulting effects afford superior advantages. This consists of inverting and interchanging elements of the patented device so that, for example, the moving parts of the patented device become the stationary parts of the modified device and vice versa. It is sometimes possible through this procedure to make a new invention.

Another method of avoiding a patented invention is to design a device that does not include all of the essential elements of the invention covered by the patent claims. In many cases, patent claims have been limited in order to avoid the prior art, and, therefore, avoidance is not too difficult. It is necessary to exclude but one *essential* element of a claimed invention in order to avoid infringement of the claim. An element is not omitted if an equivalent element is substituted in its place. For example, if the patented invention covers the use of copper for the construction of a device and it could be equally well produced in steel, zinc, or any other metal, the invention could not ordinarily be avoided merely by constructing the device of one of the other metals. However, if the use of copper was specifically stated to be a part of the invention because it had peculiar properties which renders the device operative in a particular desired manner not provided by other metals, it might be possible to avoid the patent claims by use of some metal which the art had theretofore considered unsatisfactory.

In other words, the inventor is entitled to reasonable latitude, in construing his invention, in the matter of equivalents which could be substituted by any one skilled in the art for the elements of the claimed invention.



REDUCING PATENT PROCEDURE to simple terms, this chart illustrates the ramifications of legal protection for inventions. Elements marked with asterisk have limitations which are described in the accompanying article.



Patent claims can be avoided by discovering prior constructions put into public use, or regarding which a disclosure has been published, more than one year (two years if the application was filed before August 5, 1940) prior to the filing date of the application for the patent involved. The usual evidences of such prior art are printed publications, foreign or domestic patents, or the records of manufacturers or others showing public use of the patented device. Such prior publications, patents or public use would bar recovery for infringement even though the claims of the patent are readable on the device used. Sometimes, claims are drawn broadly enough to read on prior art which did not come to the attention of the patent examiner. The inadvertent issuing of the patent did not take away anyone's right to use the prior art, although such patent may well worry those ignorant of the prior art.

It sometimes happens that patents are issued claiming as inventions a summation of old elements, each merely adding in its own particular function and providing no different co-operation of this element in the combination over that which could be properly expected by placing them together. In such cases, where no such new or unexpected result is obtained, the claims may be held invalid because of lack of invention. This is often very difficult to prove because results seem obvious after someone has shown how to obtain them. A would-be infringer is often prejudiced in his consideration of the matter. It is very difficult to prove that a patented invention should have been obvious to others, when in fact it was not obvious to those skilled in the art for a considerable period during which the problem was present.

Since the patent can not be held valid unless it is issued to the "first" inventor, if one can prove that the patentee was not the "first" inventor he has a good defense to an infringement charge. In this connection, if it can be proved that the man named as inventor in a patent is not in fact the inventor, the patent can be held invalid by a court. For example, a man may have been wrongfully included as one of two joint inventors merely because he was in a position of authority over the true inventor, or a man may have contributed only suggestions or advice as to minor features not essential to completion of the real invention. In such a situation, the real inventor may well lose his right to the protection seemingly given by the patent.

If one claim of the patent is anticipated by the prior art, that claim may be held invalid by a court. However, other claims of the patent which are not held invalid may be saved by a proper disclaimer of the invalid claims. Where one

believes that claims of a patent would be held invalid if a suit were instituted, it is not usual to notify the patentee of such belief, but to proceed to use the desired construction, relying on a defense of invalidity in any suit for infringement of such claims.

Securing patent license

It must be remembered that although one believes that he can make a successful defense in a patent suit, still it costs money and time, and you may lose. The safest way to avoid trouble is to avoid using the invention of a patent, and if you can't avoid the invention, obtain a license.

A patent license may grant either the exclusive or a non-exclusive right to make, use and sell a device. The license may cover making and using, making and selling, or all three. The license may be given free or for a fixed sum royalty, or a royalty based on the number of units sold, or the selling price of the units, or for a consideration including rights to use other patents, or for any other legal consideration. When a patented device is sold by the patentee or his licensee, it carries with it an implied license for resale or for use for the purposes for which that device is ordinarily used, unless the sales agreement contains provisions to the contrary. For example, a special radio tube which would be used only in one particular type of circuit, if sold by the holder of the patent of that particular type of circuit, would carry with it an implied license for use of such circuit. If, however, the radio tube has other recognized uses, such sale would carry with it no implied license to make, use and sell any particular patented circuit.

Admission of validity

If a license is granted under a patent, the licensee is ordinarily presumed, in a suit for royalty under the license contract, to admit the validity of the patent claims under which royalty is payable.

This legal fiction is similar to that in landlord and tenant law, where in a suit for rent the lessee is estopped from proving that the landlord does not have good title to the rented property. Therefore, while the patent license is in force, the defense of invalidity is not open to the licensee in any suit for royalty under the contract, and the agreed royalty is to be paid independently of whether one has discovered evidence that may prove some of the claims invalid.



FOR TESTING HIGH VOLTAGE CABLE, four 50,000 volt reactors are connected in series. Reactor in the foreground is 200,000 volts above ground.

STATIC CAPACITORS BOOST SYSTEMS

Pay Load

THE WARTIME LOADING of electrical transmission systems in many cases has demanded the utmost in performance from existing transmission facilities. Such was the case on the Central Illinois Public Service Company system which, due to war restrictions, found it impossible to complete planned additions to relieve overloaded conditions on transmission lines.

To remedy the situation it was found necessary to install static capacitors for increasing the load-ability of its Powerton-Kincaid transmission line in central and southern Illinois, main source of supply for the vital coal mining industry in the Kincaid-Taylorville area. The line (shown schematically in Figure 1) consists of 69 kv for 55 miles with No. 4/0 copper, a transformer bank stepping down to 34.5 kv for 37 miles with No. 4/0 aluminum, No. 3/0 aluminum, and No. 1/0 copper line extending to the mine area.

The total impedance of this circuit from the power station bus to the customer's 2300 volt bus at Mine No. 9 is 117.6 percent, figured on a 20,000 kva base. This is equivalent to 380 miles of straight 69 kv transmission line—equal to the distance from Chicago to Cairo, Illinois, at the extreme southern end of Illinois. It is called on to transmit 18,000 kilowatts under maximum load conditions and 15,000 kilowatts under normal load conditions. The major portion of this load is delivered to the Kincaid area, with other small loads delivered to Mason City, Green View, and the Springfield bus.

The problem was extremely serious (Figure 2) as evidenced by the very high sending voltages and extremely low receiving voltage with the resultant high transmission losses. An engineering study indicated that the installation of 2520 kva of automatically switched capacitors at two main load centers would relieve the serious situation materially.

This circuit was already equipped with 2520 kva of manually-controlled static capacitors and 2200 kva of synchronous condenser equipment. This is located at Kincaid Substation on the 2300 volt bus and controlled by the substation operator when on duty.

Select additional capacitors

Two additional outdoor self-contained automatic units of 1260 kva capacity each were purchased. Each was complete with automatic switching facilities and with weatherproof houses so constructed that they could easily be moved to other locations if future changes in load so dictate.

Automatic self-contained capacitor units were chosen as they were to be located at remote unattended substations and connected to the customer's 2300 volt bus to obtain maximum benefit through the transformers and line to the generating station. The sequence of their operation was obtained from detailed field tests and engineering calculations.

The automatic control of the No. 1 unit at the end of the line (Mine No. 9) was set so that at low voltage it would be the first to be connected to the line. It was set to connect to the bus at 2400 volts after 30 seconds time delay, thus

OVERLOADED conditions on electrical transmission lines are efficiently remedied by properly engineered automatic capacitor equipment

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increasing the receiving voltage. If the voltage again sagged to 2400 volts, a second unit at Mine No. 7 would automatically be switched on after a delay of 60 seconds.

Any further drop in the system voltage is taken care of by the substation operator at Kincaid substation by adding manually-controlled static capacitors and the synchronous condenser as required during times of heavy load.

In removing the capacitor units from the line, No. 2 unit is disconnected at 2600 volts after 30 seconds time delay or at 2750 volts without time delay. Similarly, unit No. 1 is disconnected with 30 seconds time delay.

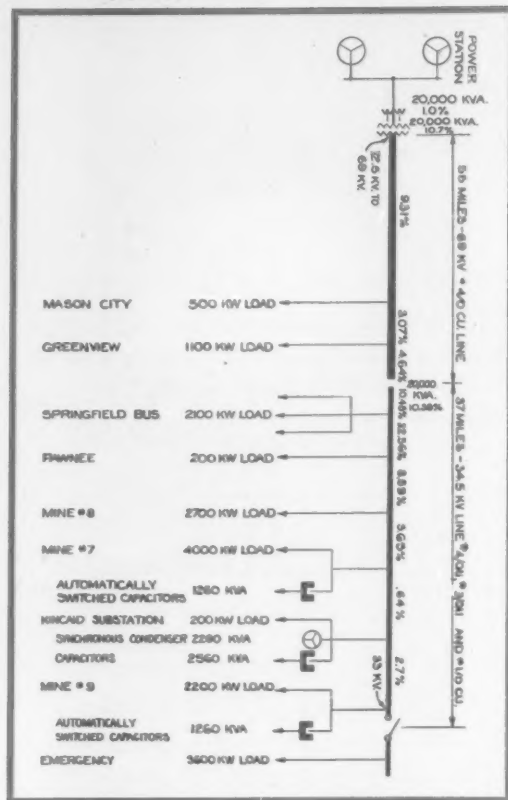
The normal function of the instantaneous overvoltage protection is to remove the capacitors from the line as soon as possible when sudden abnormal high voltages appear as the result of circuit outages and the automatic dropping of load by undervoltage devices on customer's equipment. The time delay relays would do this, but it is desired to drop the capacitors as quickly as possible to prevent damage to equipment.

The peculiar nature of the mine load is such that a very pronounced power swing is evident. On a 120 volt base this swing was from 5 to 7 volts. While normally a contact-making voltmeter is expected to operate over a much narrower range, here a 10 volt band was used.

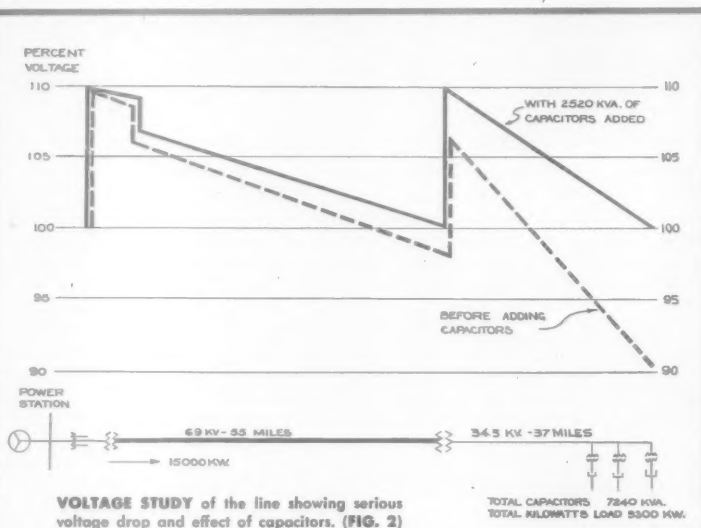
New equipment solves problem

The equipment (schematic diagram of equipment at Mine No. 7 shown in Figure 3) has given satisfactory performance for several months, handling loads beyond the normal distance under emergency conditions.

The capacitors are connected to the line by an oil circuit breaker electrically operated and automatically controlled. It is tripped on overload by either of two series current trip coils connected directly to two 400/5 current transformers. The heart of this control consists of contact-making voltmeter and timing relays.



POWERTON-KINCAID LINE with a total length of 92 miles has a total impedance of 117.6%. At 69kv this would be the equivalent of a line nearly the length of Illinois. Percent impedance is on a 20,000 kva base. (FIG. 1)



VOLTAGE STUDY of the line showing serious voltage drop and effect of capacitors. (FIG. 2)

Push-button control of the breaker is provided under all circumstances. Red and green lamps show breaker position, a switch provides manual or automatic control, and an amber lamp indicates when this switch is in the automatic position.

In case the breaker trips automatically on short circuit, a lockout relay is provided by devices 86, 86X, and 86XX, which prevents the automatic control closing the breaker on a short circuit.

Instantaneous voltage protection is provided by devices 27 and 27X. If the timer has been operating in such a direction that the small mercury switch in front is closed, relay 27X will be picked up and sealed in, causing the timer to reset to neutral. When the timing relay has returned to neutral, relay 27X is de-energized and the timing relay is free to resume its normal timing cycle. If the timing relay has been timing in the reverse direction, 27X will not pick up and 27 will merely trip the breaker.

The contact-making voltmeter relay has its coil connected to the line side of the circuit breaker by means of a potential transformer, while a separate control transformer provides all other power required for the operation and control of this equipment.

The timing relay is shown in Figure 4, its wiring diagram in Figure 3. Motor-driven and arranged to give two different adjustable time delays, it has the effect of integrating the time intervals during which the voltage is above normal, normal, and below normal. If the voltage is abnormal a greater percentage of time than it is normal in one direction or the other,

the time delay contacts will cause the breaker to operate to correct the abnormal condition.

The motor is duo-directional and is of a split-phase type with two field windings. The main winding is in two sections connected in parallel. The motor will rotate in one direction or the other, depending upon which field pole winding is energized.

Operation of timing relay

The two contacts of the voltage relay when closed will energize one or the other of the two field windings. For example, when the lower contact of the voltage relay is closed (an indication of undervoltage on the system), one field winding will be energized to cause the disk carrying the two adjustable timing levers to rotate in a clock-wise direction. As this begins to move, the notch at the bottom of the disk will force the pivoted arm carrying the leaf contacts to move to the left, closing its left-hand contact. This will place one of the small tubular resistors across the other field winding, which winding will now exert a torque, but not enough to cause the relay to reverse.

When the voltmeter opens its contact, the field winding with the resistor across it will assume control and the relay will reverse its direction of rotation and return to its starting or neutral position. If the voltage remains low long enough, eventually the timing lever will rotate to a point where it will hit the projecting pin of the eccentric cam at the top of the front of the relay and cause the cam to rotate counter-clockwise.

On the other end of the same shaft at the rear of the relay is a counter-balanced arm having on each end a mercury tube switch. Here, the left hand tube will close its contact and close the breaker. In the case of overvoltage, similar action will take place, but the relay disk will rotate in the opposite manner and the other mercury tube will close its contact, tripping the breaker. After the corrective switching takes place the voltage contact will open and the timer will reset to neutral.

The small mercury tube contact in the front of the relay operates in connection with the instantaneous voltage protection. The timing levers can be individually adjusted from about 30 seconds to 7½ minutes time delay.

How voltage relay operates

The voltage relay, a minor modification of the contact-making voltmeter used with automatic load-tap-changing equipment, is shown in Figures 5 and 6.

The relay consists of a solenoid with a plunger actuating a contact arm carrying two contacts, one closing on under-voltage and one on overvoltage. These are the upper and lower contacts which can be seen through the round hole in the front of the relay. In series with the solenoid are a variable resistor and two fixed resistors. The variable resistor is used for adjusting the voltage level and the knob in the middle of the relay adjusts the position of the lower contact, resulting in the band width adjustment.

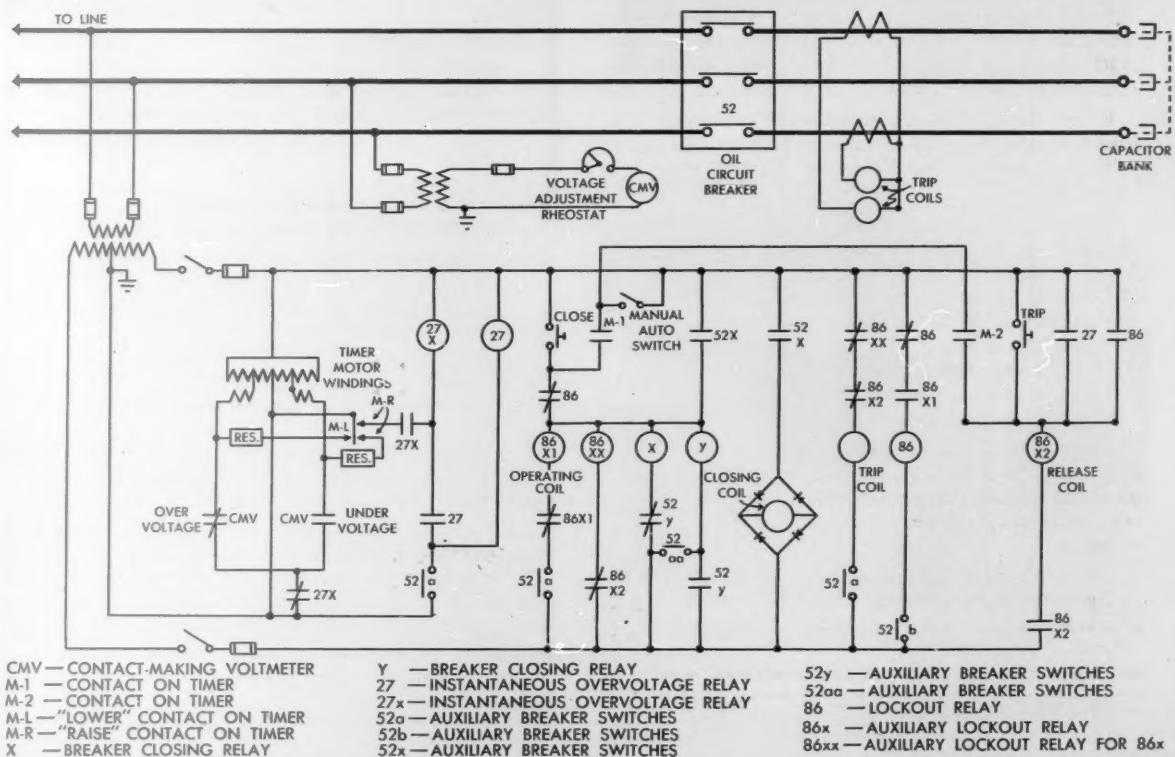
The complete installation is shown in Figure 7. The only connections necessary to put the unit in service are the three 2400 volt connections to the roof bushings. The breaker and control equipment is contained in the right-hand section, the rest of the unit being taken up by the capacitor units, the capacitor fuses, and the buswork. If individual units should fail they will be disconnected by their own individual indicating fuses. Units are easily removed and replaced, with access to the capacitors and control provided by nine weather-proofed, lockable doors.

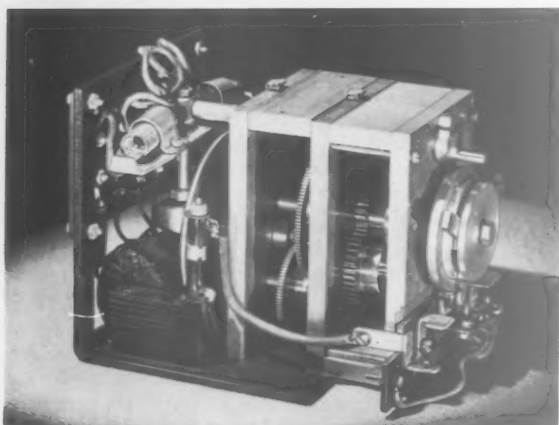
For this particular installation, the capacitors generally switch on and off twice a day, though with a narrower band width on the voltage relay operations would be more frequent.

In this manner then, one power company met and solved a severe wartime load problem. While increasing transmission line conductor size was out of the question because of the war, good engineering economy would point to the same solution in peacetime. Many utilities must face the same problems regularly in the future.

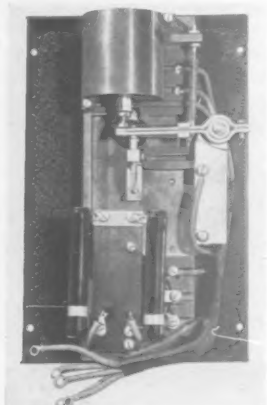
Properly engineered automatic capacitor equipment, reducing the reactive kilovars to be transmitted, improved voltage conditions, reduced line losses, increased line capacity and, consequently, reduced the investment in equipment. The ability to carry a pay load is much the same on a transmission line as it is on a railroad train—the fewer free pass riders, the more paying passengers can be carried with the same equipment; the fewer reactive kilovars, the greater the kilowatt capacity. (Continued on page 34.)

SCHEMATIC DIAGRAM of automatic capacitor control installed at Mine No. 7.
Capacitors are "Y"-connected across line through main breaker. (FIG. 3)

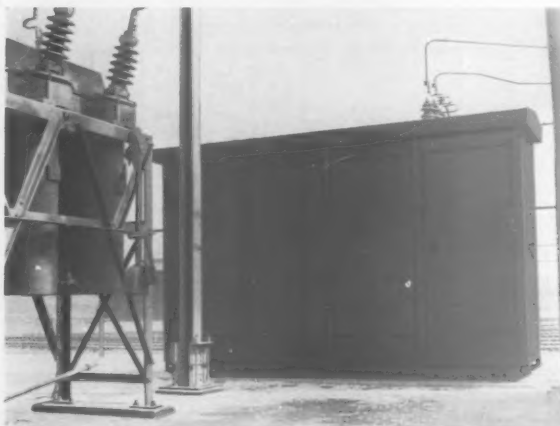




TIMING RELAY with case removed to show integrating mechanism. Whenever line voltage is abnormal, the proper field coil is energized by contact-making voltmeter. Unless voltage is normal within time preset, cam at right strikes pin, closing mercury switch controlling main breaker. (FIG. 4)



FRONT AND REAR views of contact-making voltmeter with cover removed. Center knob varies band width. Due to extreme load swings, band is set at 10 volts to prevent excessive breaker operation. (FIGS. 5 and 6)



COMPLETE AUTOMATIC CAPACITOR SWITCHING EQUIPMENT is contained in this easily moved weatherproof substation. Oil breakers are mounted at left. Control is inspected in a few minutes. (FIG. 7)

New Equipment

Devise New D-C Equipment for Remote Indication and Control

Operating on direct current, accurate electrical positioning and indicating equipment is now available for general industrial use wherever remote indication and control systems are employed.

Developed for wartime marine use, this line of equipment, consisting of receiver and transmitter with auxiliary devices, has wide application possibilities in oil fields, steel mills, steam or hydro-electric power plants, and on shipboard.

Immediate receiver response without hunting or overshooting is attained over entire operating range of the system. When the transmitter, consisting of an electrical bridge circuit, is rotated to a specific angular position, a definite voltage is applied to each of two fields in the receiver. This causes the permanent magnet rotor of the receiver to assume a position corresponding to the resultant of these two fields, thereby exactly duplicating the transmitter position. Overloading the receiver beyond its torque rating cannot damage receiver or transmitter.

Since receiver and transmitter torques are independent, the torque required to move a device is not reflected on the transmitter.

Six sizes now available range from five ounce-inches to 360 pound-inches static pullout torque. With a small rectifier unit they may be operated on alternating current.



Class B Insulation Gives Lighter, Smaller Dry-Type Transformers

Also developed during the war for marine use is a new dry-type transformer, up to one-third lighter and one-third smaller, for correction of voltage conditions, distribution of power in new and expanded plants, and establishment of adequate secondary distribution.

Compactness and lightness permit placing these units on posts, walls, overhead, and on machines in a wide range of applications. Fireproof vaults are unnecessary for inside building installations since no insulating liquids nor combustible materials are used.

Class B insulation insures longer life by resisting high temperatures and providing greater protection against moisture. Below 25 kva, both core and coil of units are impregnated by a "vacuum pressure" process to guard against moisture and dirt. Over 25 kva, coils alone are impregnated.

Costing no more than ordinary Class A insulated dry-type transformers, the new single and three phase types are available in ratings from 1½ to 300 kva. For complete details, send for Bulletin 6382.

MORE FACTS about these new products are available on request. Write the Allis-Chalmers **ELECTRICAL REVIEW**, Allis-Chalmers, Milwaukee 1, Wisconsin.

ANNOUNCING A New Line of Dry-Type Transformers!

First mass-produced during the war for U. S. fighting ships, these new Allis-Chalmers Class "B" Insulated Dry-Type Transformers overcame critical weight and space limitations.

Today, incorporating these same war-proved advantages, they're being produced for industries, utilities — to bring you simpler, safer and cheaper power distribution — new, long transformer life . . . at no advance in price!

For complete details, get in touch with your nearby A-C dealer or district office — or send today for new descriptive bulletin B6382. ALLIS-CHALMERS MFG. CO., MILWAUKEE 1, WIS.

14 SIZES

Ranging from
1½ to 300 KV —
Single and 3-phase



HEAR THE BOSTON SYMPHONY: Saturday, American Broadcasting Co.

NO OTHER DRY-TYPE TRANSFORMER GIVES YOU ALL THESE 6 MONEY-SAVING ADVANTAGES...

1 Up to 1/3 Lighter!

These new 80° C rise class "B" insulated transformers weigh 22% to 38% less than the old 55° C rise units, take fewer, lighter mountings.

2 Up to 1/2 Smaller!

The new design of these transformers also results in smaller overall size. That means easier handling for workers, quicker, cheaper installation.

3 Wider Application!

Not only lighter, more compact, but quieter, better-looking! They go in almost anywhere . . . on posts, walls, overhead platforms—even on machines.

4 Greater Safety!

No liquid to test, filter or change; nothing to promote combustion. Result: no fireproof vaults needed — you get safer installation inside buildings.

5 Longer Life!

New class "B" insulation used in these transformers affords greater protection against moisture — won't deteriorate with age — won't stretch or shrink!

6 Same Low Prices!

Yes, you can buy the new, improved class "B" insulated dry-type transformers for the same prices as ordinary class "A" insulated units.

ALLIS-CHALMERS, MILWAUKEE

ALLIS-CHALMERS MFG. CO.
Milwaukee 1, Wis.

Gentlemen:

Please send me your Bulletin B6382 describing the new line of Dry-Type Transformers.

(Name) _____

(Title) _____

(Company) _____

(Street Address) _____

(City and State) _____

A 1986-6

T. H. BLOODWORTH,
ELEC. CONTROL

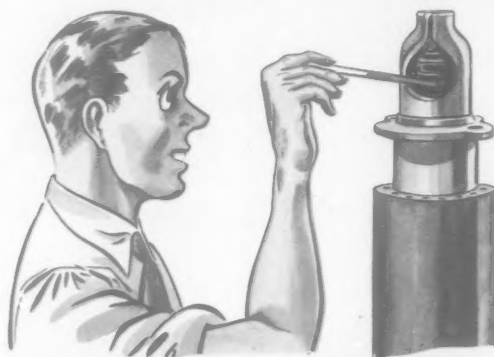


No-We Didn't Put Sun Helmets and Swim Suits on our Motors-but....

"Double Trouble", moaned the experts, but the Navy stood fast. "All we want", said they, "are starting motors for diesel engines that'll stand up in tropic heat. Make them waterproof too!"



Blood pressures went up, when we ran into short-circuits. Horsepower had to be high (14-22 hp) and frames extra small (1/5 standard size). To offset this, operating periods would never last more than 45 seconds.



Well, we sweated out the high temperature problem — finally licked it with a new method of induction brazing of armature coils. Result: our coil could withstand high temperatures under all operating conditions.



Swimming suits required! Next, we had to waterproof our motors to make them swimmers. So we slipped a spun cover over each unit and sealed it against a neoprene rubber gasket. They shed water like a duck!



"On the beam" was the way those diesel engineers put it when they saw the finished product. And you should have seen the way they beamed after they made their tests. We lost a few buttons off our vests too!



There's a Moral: Every time Allis-Chalmers engineering solves *special* motor problems, we discover new ways to build better standard motors for you. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

A 1928

Wait 'til you see the NEW

ALLIS-CHALMERS MOTORS!

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